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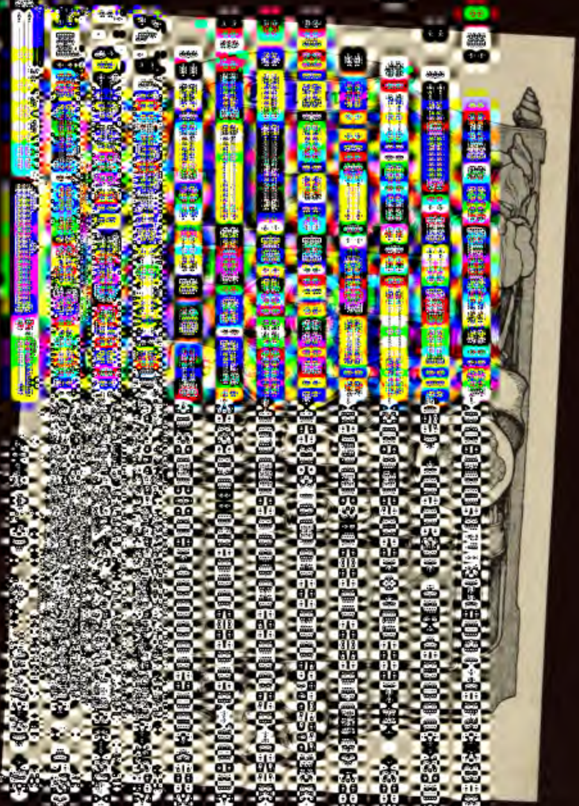

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MALARIAL FEVERS
AND
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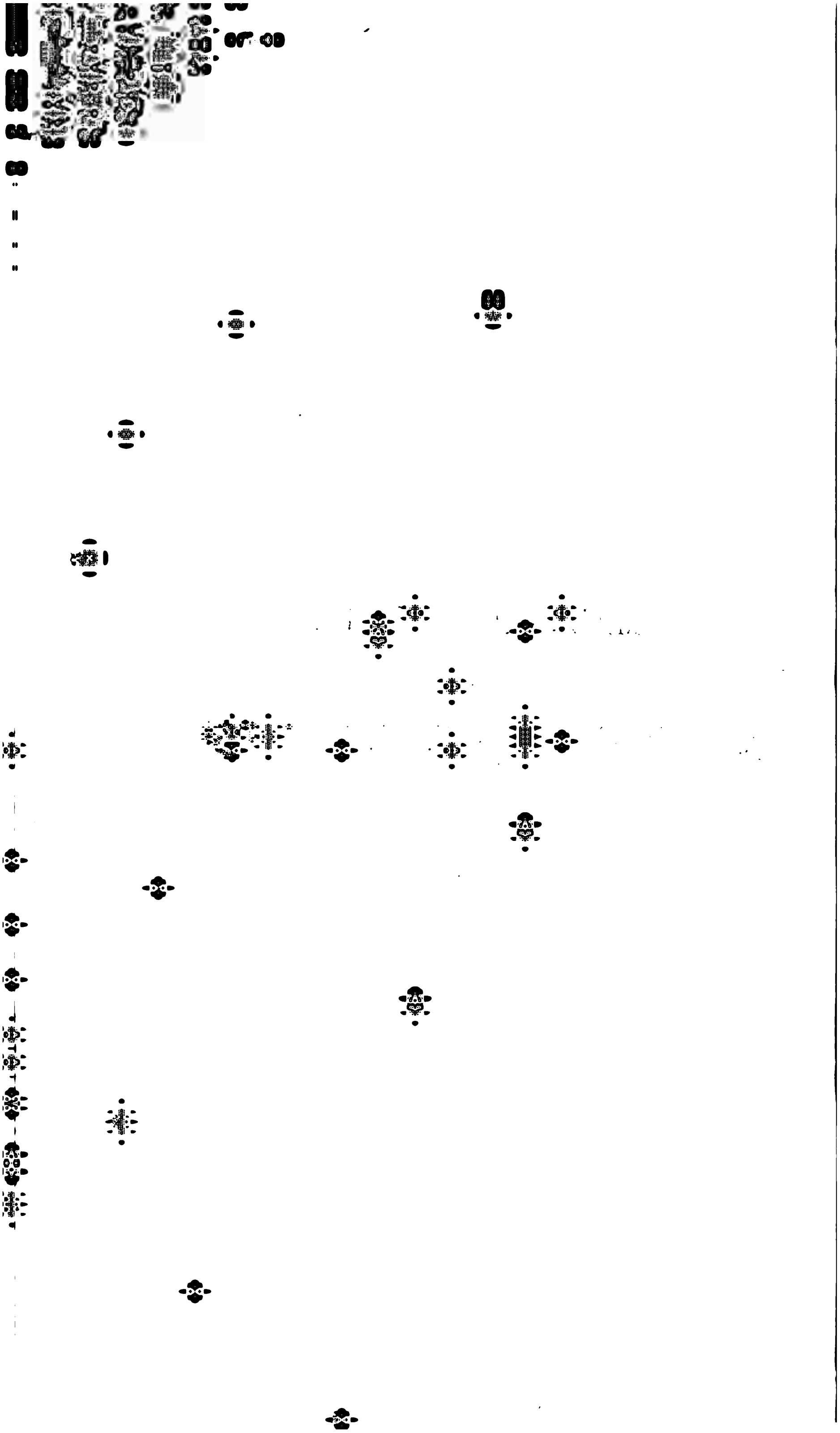

MALARIAL FEVERS
AND
MALARIAL PARASITES
IN INDIA.

BY

MAJOR ANDREW BUCHANAN, M.A., M.D.,

INDIAN MEDICAL SERVICE.

(*With twelve coloured plates, four halftone plates and twenty-four semi-diagrammatic figures.*)

SECOND EDITION. ENLARGED.

Calcutta:
THACKER, SPINK & CO.

1903

CALCUTTA
PRINTED BY THACKER, SPINK AND CO.

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PREFACE TO THE FIRST EDITION.

So much has been written on the subject of Malaria in the past few years that one feels it is necessary to make some apology for adding to the already very extensive literature on the subject. Celli, in his very valuable book on Malaria, gives a good account of Malarial fevers in Italy. Manson, who has probably done more than any other man to stimulate enquirers to make investigations into the nature and causation of Malarial fevers, has given a very excellent account of these fevers in his book on Tropical Diseases. Ross, Christophers, Stephens and others have described the Malarial fevers of the West Coast of Africa, but no one has, as far as I am aware, given a complete account of the Malarial fevers of India.

It is not claimed for what is written here that it is a complete account of the Malarial fevers of India. It is merely a record of a series of observations that have been made during the past 12 months. The observations were made in the Nagpur Central Jail, where five high power microscopes have been in regular use for the greater part of the year. A number of Burmese prisoners were trained to use the microscopes, and they very soon became expert in detecting and distinguishing the various kinds of parasites. Others were trained to take temperatures so that the record of parasites could easily be compared with the record of temperatures. One Burman, Ko Tha Aung, took an exceptionally keen interest in the subject, and carefully studied most of the literature that has appeared in Medical and non-Medical Journals on Malaria in recent years. Nga Weh Kyi, Nga Kyi, Nga Pe Gyi, Nga Hman, and Goverdhan have also given most valuable assistance.

Should the observations which are here recorded be considered by the Government of any value, I hope that something

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may be done to lessen the term of imprisonment of the men whose names have been mentioned, for without their assistance. and if they had not taken the keenest interest in the work, it would not have been possible to make these investigations.

I should like to express my thanks to Colonel Quayle, I.M.S., and Dr. Agnes Henderson for very kindly lending us their excellent microscopes and for assisting in making the observations.

There are many parts of this small book which I should like to rewrite, but as the time at my disposal for such work at present is very limited, I think it is better to publish the observations as they were originally written, in the hope that they may be of some service to the many men who are now engaged in the great campaign against the Malarial parasites.

A. BUCHANAN, MAJOR, I. M. S.

October 1901.

PREFACE TO THE SECOND EDITION.

THE First Edition was a record of a year's observations as well as a comparison of observations which had been made in Nagpur with the observations which had been made in other parts of the world. By our subsequent work a good deal of new light has been thrown on questions that were raised and discussed in the First Edition. In preparing a Second Edition I had some difficulty in deciding whether the First Edition should be allowed to stand as it was, and the more recent investigations be recorded separately, or whether it would be better to put the old and new matter all together as the results of the investigations of 18 months. An intermediate course has been followed. The original chapters have been allowed to stand very much as they were before, but in a few places some alterations and additions have been made, while several new chapters have been added, in which the results of further observations have been given.

In the First Edition the record of experiments on the inoculation of Malaria by bites of infected mosquitoes showed that most of the experiments resulted in failure. The explanation now appears very simple—it was merely a matter of temperature—but by leaving these records in the new Edition and adding the subsequent experiments in the extra chapters, it is hoped that the part played by the mosquito in carrying malaria will be brought more prominently forward, and it will be seen that there was no sudden jumping to the conclusion that mosquitoes carried malaria, and that they had a fair trial before they were pronounced guilty.

Since the First Edition was written, the Malaria Conference, which was attended by the Royal Society's Commissioners and by delegates from all the Indian Provinces, met at Nagpur, and we have had the great advantage of discussing with them a number of questions relating to Malaria. The Royal Society's Commissioners, Dr. Christophers and Stephens, as well as Captain James, I.M.S., who is attached to the Commission, have been working for several weeks in Nagpur and, if I fail to acknowledge the valuable assistance given by them, my apology must be that the valuable hints which I received from them are too numerous to be mentioned in detail.

Several Civil Surgeons, Assistant-Surgeons and Hospital Assistants have recently attended our laboratory in order to go through a course of instruction in Malaria, and as some of them had not been already familiar with the details regarding the making of films, staining, and working with an oil immersion lens, some hints to beginners were prepared. These have been included in the new chapters, in the hope that they may be useful to some who have not done much microscopic work.

KHANDWA, NIMAR,
September, 1902.

A. BUCHANAN.

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MALARIAL PARASITES

AND

FEVERS IN INDIA.

CHAPTER I.

FORMS OF PARASITES.

IN this chapter a short description of the various kinds of parasites that are seen in the blood of malarial cases and a short explanation of the terms that are employed will be given. There is only one really good way to learn what the parasites are like, and that is, to see the parasites themselves. If a whole book were written giving a description of a cow, and another book were written giving a description of a buffalo, and a person after having thoroughly studied these two books were for the first time to see a cow, and a buffalo, he would perhaps have some difficulty in deciding which is the cow and which is the buffalo. If he saw the animals themselves and if the differences were pointed out he would have no difficulty afterwards in distinguishing the cow from the buffalo. In the same way, no amount of book study can convey such a knowledge of the parasites as might be gained from a few hours' demonstration of the real parasites. Some assistance may, however, be given by illustrations, but even the best illustrations must be very different from the real parasite, especially as a great characteristic of many of the forms of parasite is their movement and the illustration cannot convey any accurate idea of this movement.

When reading the following paragraphs which will be marked A., B., C., &c., please refer to the corresponding letters in Plate I.

(A.) *The young unpigmented parasite.*—When the young parasites first enter the red blood corpuscles they are without pigment. They occupy a small portion of the red blood corpuscle, and they may be moving or quiescent. If they are moving it is easy to recognise them. The movement is what is called amœboid, *i.e.*, the movement is merely a change of shape, not a change of position. The following illustrations will give an idea of the various shapes that a parasite may assume within a few minutes. The parasite is represented inside a red blood corpuscle, and it should be explained that for facility in illustration the size of the parasite and red blood corpuscle have been made larger than they are usually seen under a high power miscroscope.

(B.) *The young pigmented parasite.*—In a few hours pigment appears inside the young parasite. The size and rapidity of movement of the pigment varies according to the kind of parasite. In one kind it is coarse and its movement is slow. In another kind it is fine and moves quickly. In another kind it is small in amount, but these differences will be explained fully later on.

(C.) As the parasities grow larger the amount of pigment increases. Some parasites fill the whole red blood corpuscle.

(D.) Some, while seen in the peripheral blood, only invade a small part of it.

(E.) *Rosettes.*—When the parasite has attained a certain stage, it becomes divided into segments, and assumes the form to which the name Rosette or a Daisy form has been applied.

(F.) Then the segments are still further separated, and each segment forms a spore, or young parasite. The breaking up of the Rosettes corresponds in time with a fresh onset of fever, and if the blood is examined when the patient is shivering, Rosettes may be seen. But the Rosettes are rarely seen in Malignant Tertian, while they can be very easily seen in Quartan. The growth of the Rosette can be watched under the microscope.

The pigment is at first scattered all through the parasite or chiefly at the circumference. The pigment begins to collect into the centre, and the division into segments becomes apparent. In each segment a nucleus is perhaps seen.

The segments are still further separated, and each segment forms a spore.

The Rosette breaks up and the spores separate.

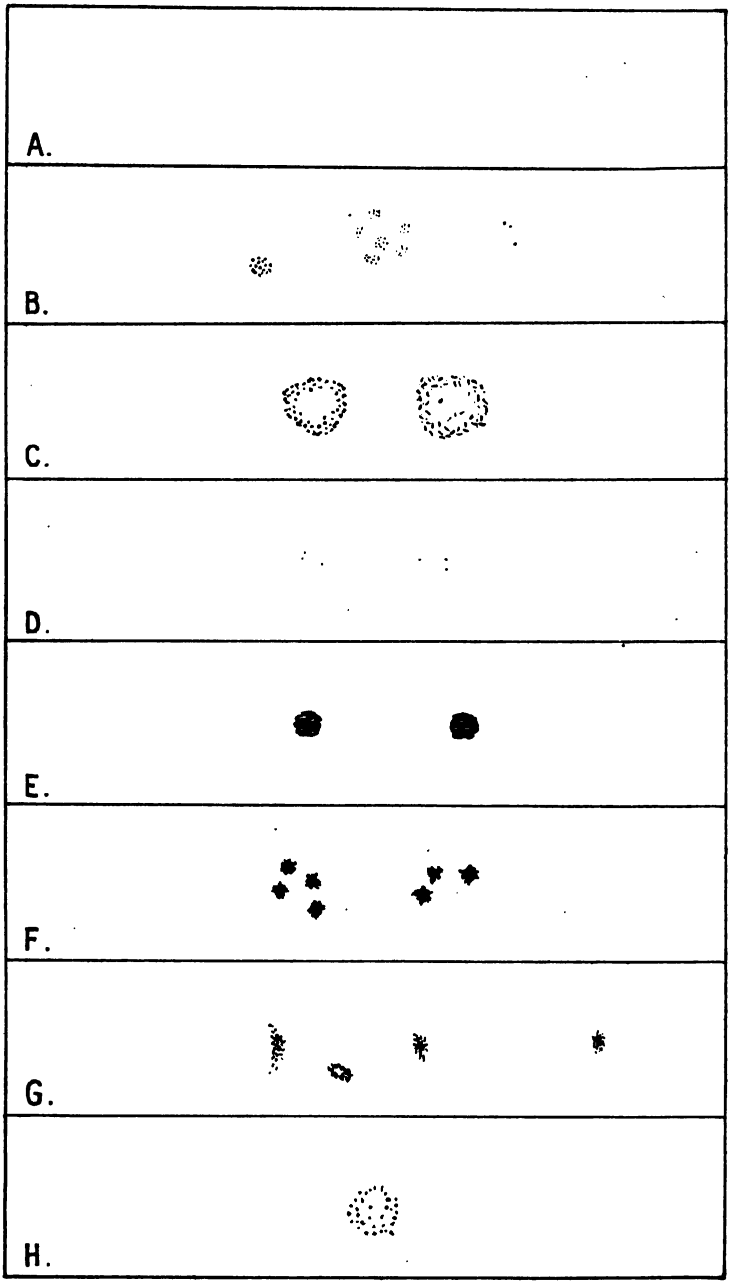
(G.) *Crescents.*—The next illustration gives a very fair idea of the appearance of a crescent or, as it is sometimes called, the crescent body. It is very easily recognised. It is not found in the two kinds of fever which belong to the Benign group, but is found in the Malignant Tertian. The name Crescent is not altogether a satisfactory one, for the crescent body is not always of a crescentic shape. It is sometimes spindle-shaped, sometimes round, sometimes oval, but most frequently it is of a crescent shape.

On the concave side of the crescents we sometimes see a fine line enclosing what we may, for want of a better name, call the " belly." The belly part is the remains of the red blood corpuscle. It is perfectly clear, and only the very fine line which marks the boundary of it can be seen in unstained specimens. In stained specimens, however, the belly part is coloured red with eosine, showing that it is part of the original red blood corpuscle.

(H.) *Flagella and the Flagellar bodies.*—The parasites have two methods of reproduction, one the asexual, and the other the sexual method. The formation of and the breaking up of the Rosette is the asexual method of reproduction. The flagella take part in the sexual method of reproduction. In the Malignant forms the flagella come from the crescents. In the Benign forms the flagella come from what look like the ordinary full grown parasites. Flagella are seldom seen in the Benign fevers ; they are frequently seen in the Malignant fevers.

The forms of parasite will be described more fully in subsequent chapters. What has been written here is intended to give to anyone who has not seen the parasites a rough idea of the nature of the parasites and of the names which are applied to the various forms of parasites.

SERIES OF MALARIA PARASITES.
PLATE I.



CHAPTER II.

CLASSIFICATION OF PARASITES.

MANSON describes five forms of malarial parasites, *viz.*, Quartan, Benign Tertian, Malignant Tertian, Unpigmented Quotidian, and Pigmented Quotidian. Celli also describes the same forms. Koch, in a lecture delivered on the 15th November last at Berlin, says, "it was also ascertained that the apparently different Italian forms of malaria are really one, and that, apart from Quartan and Tertian, which occur among ourselves, there, really, is only one form of malaria, namely, 'tropical malaria.'" In the same lecture Koch also states: "Germany has two kinds of malaria, Italy three, and a fourth kind, tropical malaria, is found in the tropics." Koch in this lecture does not say what are the three kinds that are found in Italy, nor what is the nature of the malaria which he calls tropical.

During the past two months, that is, from the middle of December till the middle of February, we have seen three distinct kinds of parasites and three distinct kinds of fever corresponding to these three parasites. Parasites were not found in every case, but they were found in nearly all of those who had high temperatures. It is very remarkable that the kinds of malaria found here tally almost exactly with those found in Italy. We have not, however, found any cases of what has been called the Unpigmented Quotidian. We thought we had seen two cases of Pigmented Quotidian, but on further careful examination we begin to doubt the existence of a Quotidian parasite. The following are the varieties which have been met with here :—

Quartan	9
Benign Tertian ...	11
Malignant Tertian ...	46

By the microscope it is sometimes extremely easy to distinguish the various forms of parasite, but in cases where there are only a few parasites to be seen there may be some difficulty. The best way to learn the distinguishing characters is to consider—

1*st.*—What points are common to all.

2*nd.*—In what respects do the Benign group resemble each other, and differ from the Malignant tertian, and

3*rd.*—What are the differences between the two parasites of the Benign group.

The points that are common to all kinds are :—

(1) All are amœboid and grow inside the red blood corpuscles.

(2) All eat up the red blood corpuscles destroying their colouring matter.

(3) All form black pigment.

(4) All are colourless (excepting the pigment).

(5) All stain with methylene blue.

(6) All have a definite period of growth : Quartans 72 hours, and Tertians 48 hours.

(7) All have two methods of reproduction—one the asexual and the other the sexual.

(8) All form "rosettes."

(9) All give out "flagella."

The Benign Tertian and Quartan have many points in common, and they have several common

points of difference from the Malignant Ter
two former, called mild malaria (Benign) b
differ from the latter, which is called severe m
(Malignant) by the same writer.

QUARTAN AND BENIGN TERTIAN.	MALIGNANT TERTIAN.
Invade whole red blood corpuscles.	Invade only one-fourth of red blood corpuscle, while they are seen in the peripheral blood.
Seen in peripheral blood throughout whole cycle.	The young forms are seen in the peripheral blood, and then they disappear from it for some days until they have become transformed into crescents.
Do not form crescents.	Form crescents.
Rosette forms seen frequently.	Seldom.

Thus there are four main points in which the Quartan and Benign Tertian resemble each other, and in which these two differ from the Malignant parasites. The two former invade the whole red blood corpuscle, and for this reason it is very easy to find them. The latter invade only about one-fourth of the red blood corpuscle, while they are seen in the peripheral blood, and then they retire or conceal themselves (in the spleen or in the marrow of the bones, but this we have not investigated here) until they have become converted into crescents. This temporary retirement of the parasites from active life in the peripheral blood is a very remarkable phenomenon. It would seem almost as if there were a barrier through which each corpuscle has to pass, and that admission to those carrying the crescent-forming parasites is strictly forbidden. If the red blood corpuscles, which carry these parasites, were enlarged, then we might be able to explain this curious phenomenon, but they are not larger, and there is no

parasite. n the case of the big swollen
been m which the Benign Tertian
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t some of the parasites in
verted into crescents and
some are converted into rosettes—the former a step in the sexual method of reproduction, the latter a step in the sexual method of reproduction. What determines the form into which any particular parasite will develop we cannot say, nor have we seen any explanation offered.

The two members of the Benign group differ from each other in the following points :—

QUARTAN.	BENIGN TERTIAN.
The invaded red blood corpuscle not enlarged.	Invaded red blood corpuscle enlarged.
The part of red blood corpuscle, which has not been eaten, still retains the ordinary colour of the red blood corpuscle.	The red blood corpuscle loses its colour and becomes clear.
The pigment is in large granules.	The pigment is in rods.
The pigment moves slowly.	The pigment moves rapidly.
The rosette has 8 to 10 parts.	The rosette has about 20 parts.

It should be explained that the above differential points do not always hold good; for instance, the pigment in a Quartan may be moving very actively when flagella are about to be thrown out, or the pigment of a Benign Tertian may not appear to be in rods when the parasite is young. There are many other minor points of difference, but these will be referred to later.

CHAPTER III.

QUARTAN FEVER.

In the Introductory Lecture, which Crombie gave at the Indian Medical Congress in Calcutta, in 1894, he said that Quartan fever was very rare and that "I had only to treat one case of Quartan in the whole of my 22 years' service in India." We were also of opinion that Quartan fever was very rare, and although we had been watching specially for Quartan cases for some years it was very rare to find any. During the past two months, while the observations, which are here recorded, were being made, we have had nine cases of Quartan fever in hospital, and the question arises how is it that we have seen so many cases of quartan in this short space of time, and that for years before we had not been able to discover a case?

The reasons are probably these. In the first place Quartan yields to quinine very readily, and a patient suffering from Quartan may have been detained for a day in hospital, and if treated with quinine his fever would probably stop. Or we may have been misled by the appearance of the charts, for if temperatures are taken only twice daily, the attack may not have come on at the time the temperature was taken. We have recently taken the temperatures every two hours, night and day, and oftener during the time that the paroxysms were occurring, and the charts have been prepared from the two-hour records. For instance, it has frequently happened that a Quartan paroxysm has come on at 8 o'clock at night and the temperature may have been normal at 5 o'clock in the afternoon, so that a chart prepared from the 5 o'clock record would be quite misleading.

Further, in Quartan fevers it sometimes happens that there is a rise of temperature every day, and in such cases the chart made from a twice-a-day record may not show the least indication of a Quartan fever.

Besides, it is only recently that we have made a systematic examination of the blood of every case admitted for fever, and as we have several men working daily and throughout the whole day it is almost impossible for Quartan parasites to pass undetected.

Then, again, we have had some cases of Quartan, combined with other kinds of fever, as Malignant Tertian, and in these cases the Quartan appearance of fever is not seen, at least in the early days of the patient's residence in hospital. Quartan fever may therefore be more common than we have hitherto been inclined to believe.

Parasites.—In the tables given at pages 7 and 8 we have already given the points in which the Quartans resemble the Benign Tertians and the points of difference between these two parasites. The illustrations give a very fair idea of the appearance of Quartan parasites. There are two sets of illustrations—one showing the unstained parasites, the other showing the parasites stained with methylene blue and the corpuscles with eosine.

Unstained Quartans.—The parasite is very easily seen. It seems to be an irregular clear space

QUARTAN PARASITES.

PLATE II.

A. The young Quartan looks like a clear space inside the corpuscle, except that this apparent space contains near its margin pigment in coarse granules. In the earlier stage the Quartan has a Ring form.

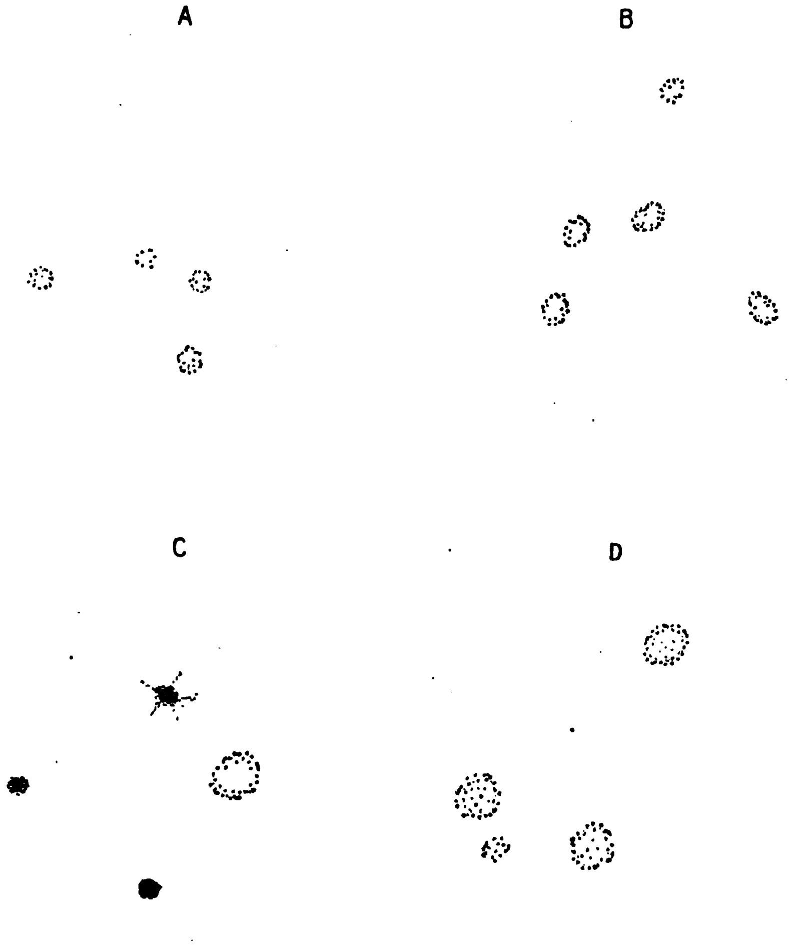
B. On the second day the Quartan occupies from half to two-thirds of the corpuscle. The invaded corpuscle is not enlarged; it gives one the idea that it is slightly contracted.

C. In the morning of the day of fever the parasite occupies the whole corpuscle. Later in the day the pigment can be seen in streaks coming in to the centre of the parasite. Later, all the pigment is collected in the centre. The groundwork or remains of the red blood corpuscle is not represented in the Rosette—the lowest in figure C. As shivering begins, the broken-up parasites can be seen. See Rosette on the left.

D. The flagellate forms are only rarely seen in Quartan.

QUARTAN PARASITES.

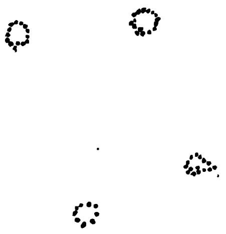
PLATE II.



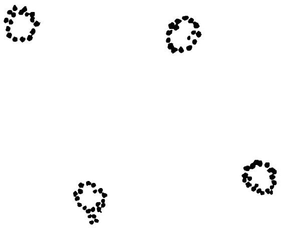
QUARTAN PARASITES STAINED WITH EOSINE AND METHYLENE BLUE.

PLATE III.

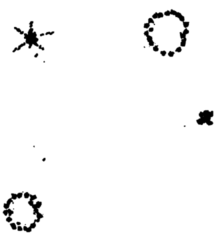
A



B



C



These Pictures show Quartan stained with eosine and methylene blue. The earliest stage, while the parasite is still in the ring form, is not represented.

The chromatin is not shewn by this method of staining. It will be shewn when we are dealing with the Romanowsky stain.

inside the corpuscle, with coarse granules of pigment. The pigment is generally at the circumference of the parasite and is not scattered through the parasite as it is in Benign Tertian. The parasite is more or less circular with an irregular outline, and we never find three or four long arms extending into the corpuscle as we do in Benign Tertian. The pigment is slow moving, —so slow that the movement can scarcely be seen while we are watching it, but if a sketch be made and another made a few minutes afterwards, it will then be seen that the pigment has altered its position. In parasites which are going to give out flagella we, however, will find that the pigment is moving very actively.

From an examination of a specimen of blood drawn from a Quartan case it is generally possible to tell not only the kind of fever but the age of the parasite, and we can tell whether fever will come on that day, on the next day, or the next day but one. The one-day old parasite occupies about one-third of the corpuscle (A), the two-day old parasite occupies about two-thirds of the corpuscle (B), and the three-day old parasite fills or almost entirely fills the corpuscle (C). Rosettes will be seen shortly before the paroxysm of fever comes on, but the best time to get them is just as the shivering stage begins (C).

It is only a few years since a medical man of high standing in India wrote in regard to these parasites, that they were not the cause of the malarial fevers; but anyone who has watched a case of Quartan fever has seen how regularly the Rosettes appear at the cold stage, how regularly the parasites grow, how they disappear when the fever stops, and how constant is their appearance in every Quartan case, cannot fail to be convinced that these parasites are the cause of the fever.

The Quartan is remarkable for its regularity and for its persistence, and for these reasons it offers the best opportunity of testing the value of drugs. We have tested the effects of the two medicines which are most frequently given for malarial fevers. The effect of quinine is marvellous. One dose of 20 grains of quinine has not yet failed to stop the paroxysms of Quartan fever for a time at least, but arsenic, if it has any effect at all, would seem to act as a good tonic for the parasite. The effect of the medicines is judged by the examination of the blood as well as by the effect on the temperature.

Crombie in the Presidential address referred to above said "there are many practitioners in this country who, from timidity or wrong teaching or some other cause, have no knowledge of, and I fear no belief in, the power of quinine as an antidote for malarial poisoning." If all cases with fever, whether of malarial origin or otherwise, are indiscriminately treated with quinine, it can be easily understood how some of the fevers may yield to quinine and some may not, and if the medical man happens to be giving to cases that are not really malarious, large doses of quinine, it will easily be understood how he may come to lose faith in the efficacy of quinine. Then, again, the different kinds of parasite may be affected to a different extent by quinine. It would be well, therefore, to put aside all ideas of treatment that have been derived from the administration of quinine, not only to malarial and non-malarial cases of fever indiscriminately, but to cases of malarial fevers which owe their origin to different parasites. The only scientific method is first to be certain that the cause of the fever is malaria, and second to make certain what particular form of malaria parasite we are dealing with, then give the medicine and watch its effect, not only on the temperature but also on the parasite.

Working on these lines, there is only one conclusion that can be arrived at from an examination of the cases that will be given here, and that is that quinine has a marvellous effect on the Quartan parasites. One dose of 20 grains stopped the paroxysms in every case, and the parasites ceased to grow. A few were seen on the first day after the quinine was given, and on the following day they had disappeared. One dose of quinine is not, however, sufficient to kill them completely, although it stops the paroxysms of fever for some days, for the fever may return and the parasites may, after a week or two be, again found in the blood.

In the same address, Crombie refers to the widespread belief :—

> "Among medical men as well as among the laity, that quinine cannot be safely or efficiently administered, except during the period of apyrexia, or at least in remittent fever its administration must be delayed till a remission has occurred such as to bring the temperature down to some point below 100° F. All the best authorities advocate a very opposite plan of treatment, and I am glad to have this public opportunity of recording an emphatic dissent from the popular belief and practice. Careful observations have shown that quinine is most efficient against the malarial organism in the early period of its growth, while it is still unpigmented

> or only collecting pigment at its periphery, *i.e.*, in Quotidian* ague during the pyrexia and the crisis."
>
> "When the amœba ceases to grow and begins to prepare for segmentation and sporulation, that is just before the rigor and new accession of fever, quinine has little or no effect on it."

We have given quinine in these when the spores, *i.e.*, young parasites were entering the red blood corpuscles, when they were one day old, when they were two days' old, and when the parasites were full grown just ready for sporulation. The effect in all was the same. The parasites were killed and they disappeared entirely, or almost entirely, from the blood.

In our books on Materia Medica we find quinine classed among the medicines that are called "antiperiodics." This term was used before the nature of the action of quinine on the malarial parasite was understood. The quinine seems to act as a direct poison to the malarial parasites, and as our knowledge advances we may hope to see the old term "*antiperiodic*" fall into disuse, and another term, which more clearly indicates the nature of the action of such medicines, introduced in its stead.

Natives use a root called "*atthis*" in malarial fevers, and we are trying it in some Quartan cases, but its effect is not as good as quinine.

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* NOTE.—Crombie had not apparently noticed that there are two kinds of Tertian, and the Quotidian referred to may probably include one form of Tertian, *viz.*, the Malignant Tertian. In his lecture only three kinds of fever are mentioned,—the Quartan, Tertian and Quotidian.

CHAPTER IV.

CHARTS OF QUARTAN.

In the first edition of this book seven charts were reproduced, but here, instead of reproducing the charts in full, an abstract of each chart will be given in the following method. This will, perhaps, be confusing at first, but after a little experience it will probably indicate more clearly the effect of the medicines.

The degree of fever is indicated by figures showing the number of degrees (Fahrenheit) above normal. Thus a temperature of 103-4 will be indicated by the figure 5, that is, 5 degrees above normal. Decimals are omitted and the nearest whole numbers are given. Only the highest daily temperatures are given.

The first two charts illustrate what may be called "severe" quartan, or cases of quartan in which there is fever every day. The quartan charts have been divided into three-day periods, and it will be seen that on the first day of each period the temperature is high, on the second day it is above normal but not as high as on the first day, and on the third day it is below or near the normal line.

The next group might be called "clear" quartans, *i.e.*, with fever on one day and no fever on the two following days.

The next group shows quartan combined with other malarial fevers.

There are two other interesting charts which show quartans combined with other diseases, one combined with enteric fever and the other quartan combined with pneumonia, but these two charts will not be given.

Case I—Sitaram. This chart shows the high temperature on the first day, a lower temperature on the second, and a nearly normal temperature on the third. This chart has been made out from the record of temperatures which have been taken every two hours. This case illustrates the tendency for quartan paroxysms to recur if the case is not treated with quinine. It also illustrates the good effect of quinine. In this case three doses of xx grains each were given on three successive days and the parasites disappeared and have not returned. Rosettes were found in large numbers, and it was noticed that the best time to get large numbers of them was just at the time of the onset of the fever while he was still shivering.

ABSTRACT OF QUARTAN CHART—CASE I—SITARAM.

			Dec.				Jany.		
Date ...	15 16 17	18 19 20	21 22 23	25 26 27	28 29 30	31 1 2	3 4 5	6 7 8	
Degrees of Fever	7 5 2	5 1 0	4 2 0	4 1 0	6 2 0	6 2 2	6 2 0	0 0 0	
Quinine ...							xx xx xx		
Weight ...			110		103		103		105

No flagella were found in this case, although several specimens of the blood were examined daily.

The weight in this case went down about 10 pounds, and in another quartan case of the severe type the weight went down 12 pounds in a fortnight. In the group of what we have called the "clear" Quartans, that is those with regular paroxysms every third day and with no fever on the intervening days, it will be seen that the weight sometimes actually increases during the time that the paroxysms are occurring.

Case II—Domia. Had five turns of fever before he came to hospital, and he had five turns while in hospital. The chart shows the high, lower, and low temperatures on the first three days. The fever stopped without quinine in this case, and this is unusual in Quartans.

CASE II—DOMIA.

Date, Jany. ...	14 15 16	17 18 19	20 21 22	23 24 25	26 27 28	29
Degrees of fever	**5 3 0**	**5 0 0**	**5 0 0**	**2 0 0**	**2 0 0**	**0**
Quinine ...	...	...	*Nil.*	...	...	...
Weight ...	...	113	...	...	112	...

The following is an extract from the daily notes:—

16*th.*—The two-day old parasites are seen filling two-thirds of corpuscle.

17*th.*—Fever is expected to-day: at 1 P.M. he feels cold; four very perfect Rosettes seen, they are circular in form and the pigment is in the centre. One parasite has advanced to a further stage and has lost its circular form. The spores are lying irregularly around the pigment which is not quite central. Another parasite is not yet full-grown, and there is a little bit of the corpuscle which has not yet been consumed.

2 P.M.—Shivering severely: temperature 100·4, a good Rosette seen, the nuclei of the spores clearly seen, but the spore circles not yet completed.

4 P.M.—Temperature 103; several broken Rosettes seen in one field; as many as three seen.

4-15 P. M.—A young form seen in a corpuscle and there is a minute speck of pigment in it, so it would seem that the young forms invade the corpuscles before the sweating stage has begun.

On the 23rd, one of the days for fever, a Rosette was found in blood drawn before the shivering, but no Rosettes were found in the blood drawn at the time of shivering. Some hundreds of specimens of blood from Quartan cases have been examined at the time when the shivering begins, and on only this one occasion did we fail to find Rosettes.

Case III.—Three charts are given to show cases of "clear" Quartan. *1st—Sambho.* In this case after five paroxysms of fever there was no loss of weight. Quinine (grains xx) was given on the day after a paroxysm, that is, when the young parasites were one day old. The parasites soon disappeared, and the paroxysms stopped for a time, but they began to come on regularly again a month later. Some one who was visiting the Laboratory said perhaps arsenic has a good effect in some cases and has not such a good effect in others, and that quinine may have a better effect in some cases than in others. It was decided that the effects of arsenic should be tried in this case.

(There was practically no rise of temperature on the intervening days, so the temperatures on these days will not be put down. Further, only the highest daily temperatures will be entered.)

	Feby.			Mar.										April	
Date.	21	24	27	2	5	8	11	14	17	20	23	26	29	1	Quinine.
Degrees of fever.	5	4	4	4	8	4	3	6	6	0	4	4	5	6	
					Liq. arsenicalis m. v. thrice daily.						Liq. arsenicalis ½ drachm daily.				

CASE III—SAMBHOO.

Degrees of fever...	7 0 0	7 1 0	5 0 0	6 0 0	5 0 0	0 0 0	0 0 0	4 0 5
Quinine ...	...	...	...	...	xx	...	...	...
Weight ...	...	95	...	...	95	...	96	...

This case illustrates the remarkable persistence of Quartan. The paroxysms kept on steadily recurring for 40 days. Arsenic was given, and the dose was increased until half a drachm was being taken daily. The temperatures were on the whole higher while the large doses of arsenic were being given, and the parasites were found regularly.

Quinine (grains xx) was given on the 2nd of April, and on the 4th April no parasites were found and the paroxysms stopped.

Case IV.—Sheik Karim's chart shows six turns of clear Quartan. Quinine (grains xx) was given when the parasites were two days old and next day (30-1-01) the following note was made :—

> " The blood was examined this morning and Ko Tha Aung reported that one parasite was seen but the pigment was not moving. I saw one parasite in this specimen and confirmed the observation. At 2 P.M. the blood was examined again. After a long search I found only one parasite: it did not fill the corpuscle and the pigment was not moving Now at 2 P.M. we can confidently say that his fever will not come to-day.
>
> 31-1-01.—No fever came last night, and after a prolonged search no parasites could be found."

Subsequent note.—From the 27th January till the 4th March no fever came. Then paroxysms began to come regularly. After six paroxysms in which the temperature went up to 103° or 104° twenty grains of quinine was given. Two native gentlemen happened to visit the Laboratory on the 20th of March, and in the course of conversation they said that Quartan fever is very persistent and that it does not yield to quinine. We offered to give them a hundred rupees if the paroxysms were not stopped by the one dose of quinine in this case. The quinine was given on the 20th : on the 21st, two parasites were found, but the pigment was not moving : on the 22nd, which in the ordinary course would have been the day of fever, no parasites were found, and we were able to say with certainty that the fever would not come on that evening. Twenty days have elapsed and the fever has not returned. Probably a small dose of quinine would not have had the same effect in stopping the fever, and this may explain why the native gentlemen were of opinion that Quartan fever is not stopped by quinine.

It may be noted that in this case and in the preceding case the fever returned about a month after one dose of quinine was given.

CASE IV—SHEIK KARIM.

Degrees of fever...	3 0 0	6 0 0	6 0 0	7 0 0	6 0 0	5 0 0	0 0 0
Quinine ...	...	...	...	...	...	XX	...
Weight ...	...	...	123	...	...	119	...

Case V.—Ghasia had been getting Quartan fever for nearly a month before he reported sick. On the morning of the 14th, the day after he came to hospital, the following note was made :—

> "I see nearly full-grown parasites. Why should we find full-grown parasites now ? Yesterday he says was his day for fever. Stained specimen very good—full of parasites, nearly all full-grown."

His fever came on that same evening at 8 o'clock, so that his statement that the 13th was his day for fever was wrong. True, he had had some fever, but it was slight as compared with the high fever on the regular day. This illustrates how the size of the parasite indicates its age.

ABSTRACT OF QUARTAN CHART—CASE V—GHASIA.

Degrees of fever.	6 0 0	6 0 0	5 0 0	4 0 0	5 0 0	4 0 0	4 0 0	4 0 0	3 1 0	5 0 1
Liq. arsenicalis minims.	...	...	...	...	...	...	...	...	V thrice daily.	

In this case the effect of arsenic was tried. Liquor arsenicalis in 5 minim doses was given thrice daily, beginning on the 6th February. On the 10th the temperature was higher than it had been for a fortnight. The remainder of the chart has not been printed, but it shows slight fever on the 13th, and no fever on the 16th. On the 14th the dose of liquor arsenicalis was doubled, and it might seem that the absence of fever on the 16th was due to the arsenic; but on the 19th, 22nd and 25th we find the fever going higher and higher on each successive turn, so it may fairly be inferred that the arsenic has not the slightest influence on the Quartan parasite.

The weight of the patient increased by about 7 pounds while the fever was going on.

Quartans combined with other parasites.—We now come to the group in which Quartan parasites are found together with other Malarial parasites. To illustrate this group two charts will be given. In both of these, Quartan parasites, as well as the parasites of Malignant Tertian, were found. In both of these the temperature was irregular at first, and in both the parasites of the two kinds of fever were found a day or two after admission to hospital. In both the Malignant Tertian disappeared early, and as the Malignant Tertian parasites disappeared, the Quartan nature of the fever became more distinct. The paroxysms in the early time in both were mild, and later they become more severe.

Case VI.—Jangli. In this case Quartan and Malignant Tertian parasites were found. The temperature at first had a Quotidian appearance—another proof that the chart for purposes of diagnosis is not reliable.

This case also illustrates the persistence of Quartan fever.

It also illustrates what has been already said about arsenic. Five minims of the liquor arsenicalis were given from the 17th till the 27th. The dose was doubled on and after the 27th. Five paroxysms came after the arsenic was begun, and the temperature in the last but one paroxysm was higher than it had been for a month before.

The weight increased a few pounds while the Quartan fever was going on.

ABSTRACT OF CHART—CASE VI—JANGLI. QUARTAN AND MALIGNANT TERTIAN.

Degrees of fever.	4 5 5	6 0 1	4 0 0	1 0 0	3 0 0	3 0 0	5 0 0	4 0 0	5 0 0	5 0 0
Liq. arsen.	...	...	...	...	...	..	V thrice daily.		...	Double dose

Case VII.—Panchu. Quartan and Malignant Tertian parasites were found in this case. Only a few of the Tertian parasites were present. After seven Quartan paroxysms a native medicine called "*atthis*" was tried, and experiments with it are being made at present.

ABSTRACT OF CHART—CASE VII—QUARTAN AND MALIGNANT TERTIAN.

Degrees of fever...	**2 0 3**	**3 3 2**	**0 0 0**	**0 1 0**	**2 1 0**	**2 0 0**	**1 0 0**	**3 5 0**

In this case the weight went up over 5 pounds.

Subsequent note.—Five paroxysms occurred after the *atthis* was begun. The amount of *atthis* given was 20 grains three times daily, and this dose was continued for about three weeks.

CHAPTER V.

BENIGN TERTIAN PARASITES.

In the tabular statement which is given at page 8 the differences between the Quartan and Benign Tertian parasites have been briefly explained. The young forms of the Benign Tertian are very characteristic. Before they are pigmented they move more actively than the Quartans, but this difference in movement would not enable us to make a differential diagnosis between these two kinds of parasites. After the pigment has begun to form, the Quartan settles down and there is not much activity in the movement of the pigment. The Benign Tertian, however, still continues its amœboid movements. It is, if the expression may be used "all arms," and the ends of these arms are often slightly enlarged. The pigment is collected in these terminal enlargements, and it would appear sometimes, at first sight, as if there were three or four small parasites at work in different parts of the red blood corpuscle (A).

If we watch them, however, for a few minutes, it will be seen that they are connected together, and these arms will be drawn in towards the main body if such can be said to exist (A). This appearance is very characteristic, and it is quite enough to justify a diagnosis of Benign Tertian. The red blood corpuscle soon after it has been invaded becomes enlarged and

BENIGN TERTIAN PARASITES.

PLATE IV.

In the early stage there are young unpigmented rings. The parasite is actively amœboid, and soon throws out arms in different directions. The pigment granules, or fine rods, are more numerous in the enlarged ends of these arms. This appearance is very characteristic of Benign Tertian (A and B). The invaded corpuscles become large and pale—more so than is shown in the picture.

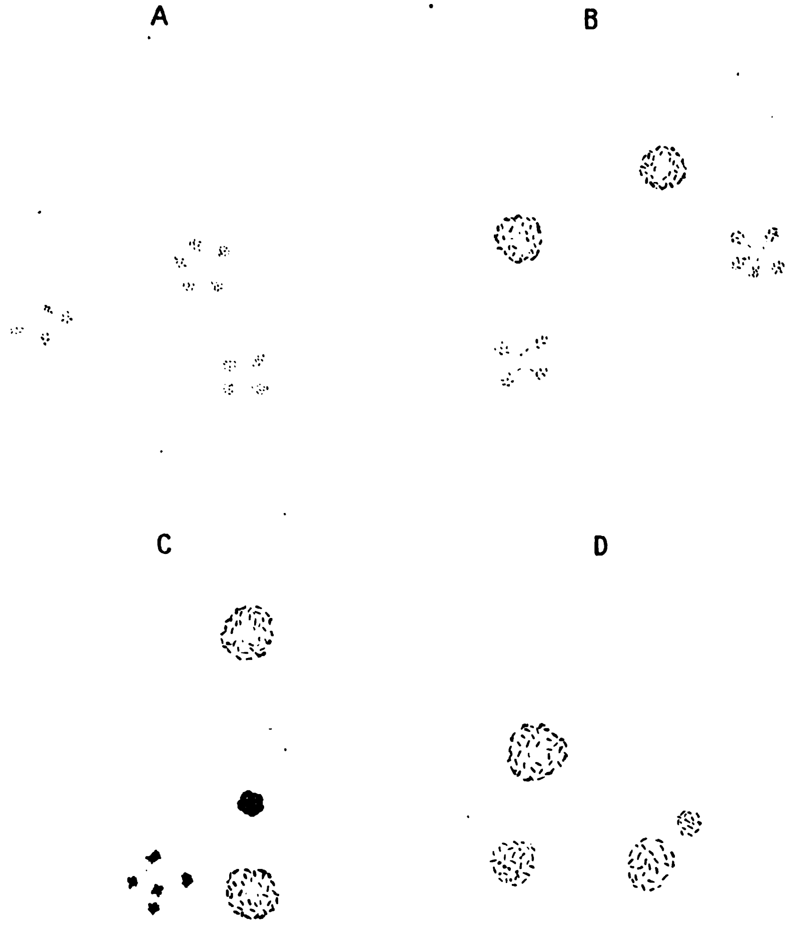
The pigment is in fine rods and it appears to be more scattered through the parasite than in Quartan.

The Rosette form represented in C is rather diagrammatic. The perfectly regular rosette which is so often found in Quartan is not so often found in Benign Tertian.

The gametes or sexual forms are seen occasionally. It is not known if they ppear at any definite stage of the attack as in Malignant Tertian.

BENIGN TERTIAN PARASITES.

PLATE IV.

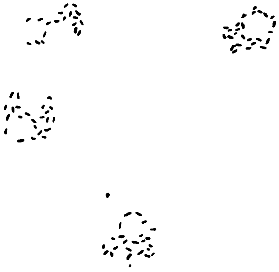


BENIGN TERTIAN PARASITES STAINED WITH EOSINE AND METHYLENE BLUE.

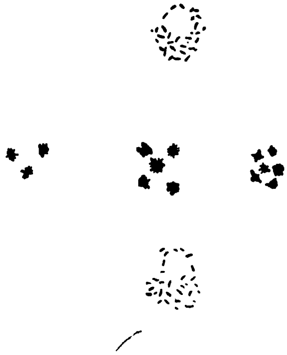
PLATE V.

A

B



C



The pictures represent the parasites when stained with eosine and methylene blue separately, and consequently the chromatin is not seen.

The rod shape of the pigment is more distinctly seen than in the unstained specimen.

This method of staining is seldom followed now, as the Romanowsky stain has been substituted. It will be described in Part II.

clear in colour. At this early stage the pigment in the Benign Tertian is not in rods, or at least rods cannot be as distinctly seen as they can be when the parasite is full-grown.

When we watch one of these young forms free in the plasma two parts can be seen, especially if the specimen is stained. One part takes a blue stain, the other part, which looks like an empty sac, does not take the stain except at the circumference.

Rosettes are seen frequently, but not as frequently as in the Quartans. There are about 20 parts in the Rosette, but it should be remembered that it is only after a Rosette has become a little broken up that it is possible to count the number of parts, and if we should see a young Rosette it would frequently be impossible to say definitely whether it is a Quartan or a Benign Tertian. If it is a little broken up and the spores are not held together inside a circular capsule, then it may be possible to say definitely which form of fever the parasite belongs to (C).

In an article by Major Melville, R.A.M.C., which appeared in the *Indian Medical Gazette* in March 1899, he says: "There was an attempt to distinguish between the Tertian and Quartan forms, which in ordinary clinical work must, it appears to me, be impossible in the absence of 'Rosettes.'" Major Melville does not say what kind of Tertian he is speaking of, but if it is the Benign Tertian, it is curious that one of the first things we show new men here is a Benign Tertian and a Quartan, and we find that they can learn to distinguish between these two in a few minutes *provided the parasites are not in the Rosette stage.*

The Rosette generally forms after the whole of the invaded corpuscle has been eaten up by the parasite, but this is not always the case, and we frequently see, especially in stained specimens, a Rosette with a part of the original corpuscle still beside it. This is very uncommon in Quartans.

Flagella are not often seen in Benign Tertian cases. When we are describing the Malignant Tertian fever, we shall explain how the flagella appear at a certain period—during what we have called the "flagellar fever." We are not certain if the flagella appear at more or less definite time in the Benign Tertian, but although we looked in all the cases of what appeared to be first infections flagella were not found while the paroxysms continued. In two cases in which flagella were found the primary paroxysms had stopped for some time. The men again came to hospital and flagella were then found. It would seem that there is a secondary fever in which the flagella are found.

There is a curious contrast between the two Tertians as regards their influence on the invaded corpuscle. The Benign parasite causes the invaded corpuscle to swell, whereas the Malignant Tertian parasite often causes the invaded corpuscle to undergo a kind of crenation. We often see a field in which all corpuscles but one are crenated, and that one has a Benign Tertian parasite inside; and we often see a field in which only one corpuscle is crenated and that one holds a Malignant Tertian parasite—it is the brassy body of the Italians.

The pigment is in rods, but it is difficult to see the rods of pigment in young forms, and even in full-grown forms sometimes, owing to the rapidity of their motion.

The rods are best seen in stained specimens. In some stained specimens we see the rods of pigment on the slide, but the body of the parasite has apparently disappeared.

CHAPTER VI.

BENIGN TERTIAN FEVER.

THERE are two Malarial parasites which take 48 hours to complete their asexual cycle of development. One is called the Benign Tertian and the other the Malignant Tertian. The latter is called Malignant because the paroxysms of fever may be "prolonged and approach each other so as to simulate a continued fever" (Celli, page 46). Some charts of both these kinds of fever will be given, and it will be seen that, although these two kinds of fever resemble each other in, as a rule, giving higher temperatures on alternate days, the charts otherwise show very marked differences. The two most curious points about the Benign Tertian fever are—

(1) the tendency for the paroxysms to recur, and
(2) the tendency for the temperature to run up high.

The first chart shows about ten paroxysms, and the fever was then stopped by quinine. The second shows about thirteen paroxysms, and the fever was then stopped by quinine, as the patient got a Malignant Tertian infection in addition to the Benign. The third shows six paroxysms, and then it presents some irregularity. The fourth case shows only four paroxysms. Now when we compare these with the Malignant

Tertian charts it will be seen that the Malignant charts nearly always shows a downward tendency, a "slope downwards" after the third or fourth day.

The other point is that the fever frequently runs up very high in the Benign Tertians: temperatures of 105 or 106 are not uncommon. (See the charts of Thibroo, Narayan, and Sheik Gulab.)

We have said that these are the two most curious points about the Benign Tertian fever, because it may seem extraordinary that the Tertian, which has the higher temperatures and in which the paroxysms are most likely to be repeated, should be called "Benign." But there are other points that have to be considered. The duration of a paroxysm is much shorter in the Benign Tertian: there is a severe shivering fit, a rapid rise of temperature, and this is soon followed by free perspiration. On the intervening days it is rare, except in the first few days of the fever, to get a rise of temperature, whereas in the Malignant Tertian the temperature is often high on successive days. Then if we look at the weights we find that the weight rarely falls more than a pound or two in Benign cases, and in some the weight has actually increased.

In Quartan fever it is very rare to find the day of fever changing, that is, if it comes on the 6th, it will come on the 9th, 12th, &c.; but in the Tertians we sometimes find a change of day. If the fever has been coming on the 3rd, 5th, 7th, it may then come on the even days—the 8th, 10th, &c. This change is seen in both the Tertians. It is interesting to note that in the Tertian fever of sparrows there is often a change of day.

The charts of four cases will be given—one chart each for the first three. The fourth case was a very long one, and as there were altogether four admissions to hospital—apparently as a result of one infection—two charts are given to illustrate this case.

Case I, Sheik Gulab.—This chart shows a fairly regular rise of temperature on alternate days. Note that the temperature was 105·6 on the day of admission. The day of fever did not change. After the 10th paroxysm quinine was given and the fever stopped. The loss of weight was 3lbs.

Case II, Thibroo.—Note that the temperature on two successive days was over 106. Then for two days there was no fever, and the chart after this shows a regular Tertian appearance. On both days, when the temperature was high, many "boilers," that is, parasites with the pigment moving rapidly were seen. There appears to be some irregularity in the fever on the first few days of Benign Tertians. The chart may show a Quotidian appearance, even though there is not a double infection.

16*th December.*—Many phagocytes seen : they seem rather dark in colour : three seen in one field.

27*th December.*—The large clear cell, which the parasite has invaded, is not crenated, although all the other red blood corpuscles in the same field are crenated. His fever stopped without quinine.

Towards the end there is an attempt at a change of day.

Case III, Yeshwanta.—He had four paroxysms of regular Tertian, an interval of 11 days without fever, and was discharged on the 15th February. He was again admitted on the 27th February with slight fever, and several flagella were seen. He had also Crescents, as well as Benign Tertian parasites, and both kinds of flagella were seen.

3*rd March* 1901.—Although many Benign Tertian parasites are found in the blood and also Crescents, he has not had fever for a few days.

ABSTRACT OF BENIGN TERTIAN CHART.

Case I.—Sheik Gulab.

		December.																								January.		
Date	...	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
Degrees of fever	...	7	2	3	0	4	0	2	0	3	0	2	2	3	0	3	0	6	2	5	2	0	0	0	1	0	0	...
Quinine	...	...	...		...		...		...		...		...		...		..		...	X	X	X	X	X	X	X	X	X
Weight	.	...	...		...		...		95		...		...		...	95			...		...		93		...		...	...

Case II.—Thibroo.

		December.																						
Date	...	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	...	...	...	...
Degrees of fever	...	8	8	0	0	3	0	3	0	5	1	5	3	3	2	2	3	0	0	1	0	...	...	...	...
Quinine	...		...		...		...		...		...		...		...		...		...		...	...	...	...	...
Weight	...		...		118		...		...		...	120			...		...		121		...	...	...	...	...

Case III.—Yeshwanta Benign Tertian.

		January.									February.																	
Date	...	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	...
Degrees of fever	...	5	0	6	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0		...		...		...		...
Weight	...		...		114		...		...		...	118			...		...		119		...		...		...		122

ABSTRACT OF BENIGN TERTIAN CHART—(*contd.*)

Case IV.—Narayan. Abstract of first Chart.

December.																														
Date	...	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24·	25	26	27	28	29	30	31
Degrees of fever	...	5	4	7	0	7	1	6	1	7	0	3	0	5	0	2	0	2	3	1	2	0	7	1	4	3	2	0	0	0
Quinine	...		...		...		...		...		...		...	...		...		...		...		...			...	X	X	X	...	...
Weight	...		...		...	85			...		...	8	8	...		...		...			86	...			...		86		...	...

	2nd admission.						3rd admission.					February.						
Date	2	3	4	5	6	From 6th till 18th no fever.	19	20	21	22	23	24	25	26	27	28	1	From 1st till 12th no fever.
Degrees of fever	2	8	7	7	0		2	0	7	6	8	4	7	0	0	0	0	
Weight		93	...		...		..		95	...	......		...			94	...	
Young forms		0	5	6	..		...		39	5	7	...	1	2	1	...	...	
Pigmented parasites	14	30	50	60	...		...		319	760	404	...	14	2	3	...	...	
Rosettes		1	0	80	...		...		10	...	16	...	0	...		...	...	
Flagella	1	0	1	0	...		...		...	2	15	...	0	...		...	...	

	March.				4th admission.					
Date	13	14	15	16	17	18	19	20	21	22
Degrees of fever	2	3	7	2	7	1	5	1	5	...
Weight	......		......		......		......		......	
Young forms	......		5	2	9	4	1	0	......	
Pigmented parasites	3	6	7	5	7	6	5	6	8	...
Rosettes	......		......		2	...	1	...	......	
Flagella	......		......		......		1	...	......	

Case IV, *Narayan.*—Two charts are given to illustrate the temperature in this case, and the second chart represents three separate admissions to hospital.

1st admission.—After nine turns of fever the day changed, and the fever which was coming on the odd days of the month began to come on the even days. He then got a Malignant infection and Crescents were found. Quinine was given. He was discharged from hospital on the 24th January and was again admitted on 2nd February.

2nd admission.—There was fever daily for four days, but the chart shows no appearance of Tertian, although many Benign Tertian parasites were found.

3rd February 1901.—In blood drawn to-day (temperature 105·6) we see an enormous number of young parasites. In one field I counted one young ring form, eleven pigmented parasites and one very nice Rosette in which the pigment is central and the nucleoli are seen distinctly. Outside there is a small rim of ground substance.

4th February 1901.—This morning a parasite was seen giving out flagella, and we watched it for half an hour This is an unusually long time for flagella to continue moving. A phagocyte then came. The temperature was 102·6 when the blood was drawn.

From the 6th to the 18th there was no fever. On the 5th a large number of parasites were counted. In one slide, which had been kept for a few hours, 40 Rosettes were seen. It seems curious that no fever should have followed, although so many Rosettes were found.

3rd admission.—Here the chart shows a Tertian appearance though not a clear Tertian. The number of parasites seen was very remarkable: on the 22nd as many as 767 were counted in ten slides—twenty minutes being devoted to the examination of each slide. Fifteen flagella bodies were seen on the 23rd, and the question arises whether there is a Flagellar period in Benign Tertian as there is in Malignant Tertian cases. From the 26th February to the 12th March—an interval of 15 days—there was no fever excepting on one day and then fairly regular Tertian came on.

4th admission.—Here one flagella body was found, and the majority of parasites seen were of the ordinary kind.

CHAPTER VII.

MALIGNANT TERTIAN PARASITES.

THIS is also called the æstivo-autumnal fever or summer-autumn fever. Before describing the nature of the fever as illustrated by the charts, a short account of the appearance of the parasites will be given. In this fever we see the parasites in four very distinct stages or conditions, *viz.*, the young form (unpigmented and pigmented), the Crescent bodies, the Flagella bodies, and the Rosettes. These will be dealt with in succession.

YOUNG FORMS.

When unpigmented the young forms move inside the red blood corpuscles very much in the same way as the young forms of the other parasites, but this motion soon ceases, and they are seen in their very characteristic shape as "Ring forms." The Ring is colourless, and inside the ring is a disc which has the same colour as the red blood corpuscle (A).

Pigment forms early, and it will be seen in the ring part, but note that it is always small in amount, and usually there are not more than two or three granules of pigment (A).

The invaded blood corpuscles sometimes lose their shape and undergo a sort of crenation, forming what have been called by the Italians "Ottonati" Brassy bodies. One often sees only one crenated corpuscle in a field under the microscope, and that one

MALIGNANT TERTIAN PARASITES.

PLATE VI.

A. In the early stage the parasite is fairly actively amœboid, and it may not be easy to distinguish it from the Quartan or Benign Tertian. After a few hours one or two granules of fine pigment will be seen. The parasite then has the somewhat characteristic Ring shape. Some of these grow and form Rosettes very much like the Quartan and Benign Tertian, but these are not represented in the picture.

B. Others, which are destined to become the sexual forms, grow and become crescents. The colouring matter is removed from the corpuscle, and we see the clear belly part: such crescents are immature and will not give out flagella.

C. The belly part is absorbed, and then we find the fully-formed crescent. Note how they often lie close to a corpuscle.

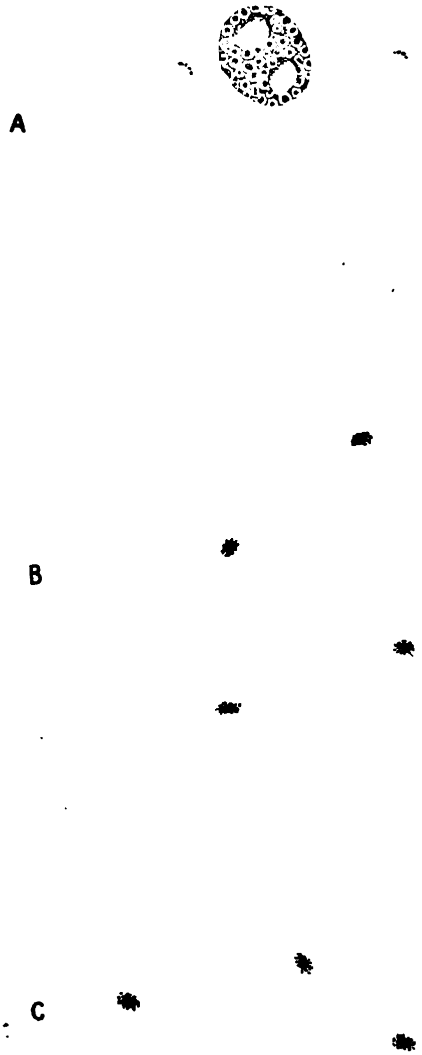
D. The crescents become round, and the males give out flagella. The points of distinction between the males and females will be given in Part II.

MALIGNANT TERTIAN PARASITES.

PLATE VI.

MALIGNANT TERTIAN PARASITES STAINED WITH EOSINE AND METHYLENE BLUE.

PLATE VII.



A. The first picture shows some ring forms and there is an attempt, though not very successful, to represent from left to right, a polymorphonuclear leucocyte, a mononuclear leucocyte and an eosinophile cell and a phagocyte. It should be explained that the phagocyte is not a separate and distinct form of cell from the others. For further particulars see Part II.

B. Note that the belly part stains red, showing that it is part of the original blood corpuscle.

C. The crescent stains a pretty blue colour.

corpuscle will have a Ring form inside of it. These Brassy bodies soon disappear from the peripheral blood and remain in some internal organ for some days. It is said that they go to the spleen and to the bone marrow, but this point has not been investigated here. When they next make their appearance in the blood they are in the form to which the name Crescent has been given. It should be explained that the Brassy body stage is not often seen.

CRESCENTS.

Owing to the fact that the Ring forms disappear from the peripheral blood when the Crescents are about to be formed it is very seldom that we see the parasites in the transition stage. We have watched for it carefully but have only seen it on a few occasions. The Ring form lies at the side of the corpuscle ; it becomes elongated, and one side of it lies in close contact with part of the circumference of the corpuscle.

For some days it apparently remains in the internal organs, and when next seen it may be a Crescent with " belly" (B) or a fully-formed Crescent (C).

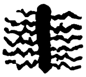
The belly part is colourless and in unstained specimens we see only a very faint boundary line. It is sometimes difficult to see this belly part, but in stained specimens it can be readily seen, for it stains well with eosine, showing that it is the remnant of the blood corpuscle. We have particularly noted that this belly part is, in the unstained specimen, always absolutely colourless, except in the very early stage of Crescent formation because in the first plate in Manson's book this part is shown of the same colour as the red blood corpuscle but this is clearly not correct. The

Malignant Tertian parasite destroys the colouring matter of the corpuscle while the Crescent is forming. Now the Benign Tertian parasites early destroy the colouring matter of the red blood corpuscle, and we can easily understand how they may pick up this colouring matter as they are constantly sending out arms and retracting them , but the Crescent seems to fix itself to one side of the corpuscle, and without exerting itself much, it seems to draw the colouring matter from the corpuscle. The protoplasm of the corpuscle is afterwards gradually absorbed and then we get the typical Crescent body (C).

The pigment is usually collected in the middle of the Crescent, and this pigment may be in short rods or in granules. These pigment rods may be quiescent or they may be moving slightly. When blood containing Crescents is drawn, we see at certain stages of the fever what are called—

FLAGELLA BODIES.

The term " flagella " is applied to what appear to be the organs of locomotion of some microbes as the bacillus of Enteric fever or the Bacillus coli.



ENTERIC BACILLUS (DIAGRAMMATIC).

By a special method of staining, the flagella of Enteric bacilli can be demonstrated. The flagella of the malaria parasites are of quite another nature; they more resemble spermatozoa, and it is well to bear this in mind, as otherwise some confusion might arise from the application of the term flagella to organisms which are so totally different in their functions.

In stained specimens we see that some Crescents take more of the blue stain than others. Manson, quoting Bastianelli, says "the male Crescent stains more deeply," whereas Celli in his description of the female Crescent says "the protoplasm is stained a darker blue." That some stain darker than others there is no doubt, but whether the darker-stained ones are the males or the females, we have not yet been able to definitely prove.

If at a certain stage of the fever we watch Crescents under the microscope, we find some of them altering in shape and becoming round. This is the flagella body, and in it we see an inner circle and an outer circle.

After a few minutes the pigment granules are seen moving—at first slowly, then rapidly. A few minutes later, if there are any blood corpuscles in the neighbourhood, they will appear to be very much disturbed, their edges will be turned up again and again, or a sort of shadow may appear to pass over some of them. What has happened or what has caused the disturbance? It is the flagella which have suddenly forced their way from ther ound flagellate body (D).

No illustration can possibly give any idea of this very wonderful performance, for in the first place the flagella are as nearly as possible transparent, and in the second they are moving so rapidly that it is difficult, and often impossible, to see them until their movement begins to slow down. If you could imagine half a dozen snakes tied together by the tails and all struggling vigorously to get free it would give some idea of the movement of the flagella. In the blood of the sparrow the flagella can be seen more readily, and after breaking away from the flagellate body, they can be seen for some time wriggling about among the corpuscles; but the flagella of the human parasite are so small and so transparent, they are lost to view very quickly. The movement of the flagella goes on for a few minutes, as a rule about 5 minutes, but it may go on for a longer time.

Some of the Crescents are converted into round bodies with pigment collected in the centre and a clear part outside but differing from those already described in that they do not give out flagella. These are said to be the female parasites. They often have two knobs at one side (D), it is not clear how these knobs are formed.

ROSETTES.

Rosettes are very seldom seen in the peripheral blood in Malignant Tertian cases. We have only seen two or three, although several hundreds of specimens of blood have been examined. In the case of Ramia, which will be given further on, a good Rosette was found and 13 spores could be distinctly counted. The Rosette was at first about half the size of a blood corpuscle, but it was left under the microscope for over an hour, and then it had spread out and was as large as a red blood corpuscle.

In the blood of Malignant Tertian cases, the forms of parasites that are seen usually are, first the Ring forms, then the Crescents, and after these the Flagellate bodies. When we come to examine the temperature charts, it will be shown that the temperature chart can be divided into three fairly distinct periods, and it will further be shown that each of the three periods in the chart corresponds with the appearance of one of the three forms mentioned here. The primary fever with its chart showing a gradual slope up, and then down, tallies in point of time with the presence of Ring forms; the interval of little or no fever tallies with the time when Crescents are seen, and the " Secondary fever " or Flagellar fever tallies with the appearance of flagella.

Subsequent notes, May 1902.—A more detailed description of the differences between the male and female gametes will be given in Part II.

(2) We have taken blood from the spleen of one case as the fever was coming on, and several Rosettes were found.

(3) We have records of one case in which numerous Rosettes were found in the peripheral blood.

(4) Brassy bodies are seen shortly before the onset of fever.

(5) The term " Flagella body " is not a good one as it is not applicable to the female. The term gamete is more suitable.

CHAPTER VIII.

THE FLAGELLAR FEVER IN MALIGNANT TERTIAN.

NEITHER Manson nor Celli, nor any of the authors that we have consulted, describe or mention anything regarding the fever that occurs about the time that flagella are seen in Malignant Tertian cases.

Manson says in regard to Crescents that "the Crescent body does not begin to show itself till it approaches maturity, about a week after the first crop of amœboid parasites associated with the paroxysm has appeared," and this we have verified in many cases, but as regards the exflagellation Manson says :—

> "In certain bloods exflagellation is easily procured ; in others the opposite is the case. As regards the Crescents, doubtless success depends in a measure on the degree of maturity of the parasite, young or effete Crescents failing to evolve. There are other conditions affecting the process, however, which are as yet unknown."

The investigations which have been made here throw some new light on this point. While the investigations were being carried on a good many people (medical and non-medical) visited the Laboratory, and as we always tried to show them flagella we noticed that there was a certain stage when flagella could be found almost to a certainty. After the Primary fever had disappeared there was an interval with low, or only slight, fever, and then came a second rise of temperature and when this fever comes on flagella can be found. We have not failed to find flagella in the blood of any case that has been examined during this period. This fever to which we have given the name of "Secondary" or "Flagellar" fever does not always occur, but even when it does not occur a few flagella will be found if the blood is carefully examined. If the temperature be high, more flagella will be found; if it be low, less will be found; and if there be no fever, it may be difficult to find them. There is a distinct relationship between the amount of fever and the number of flagella to be seen, and therefore it would seem reasonable to consider that this fever is due to the flagella bodies; and if it is, we have next to consider whether the fever may in any way be connected with the process of exflagellation. Now it has apparently hitherto been supposed that exflagellation takes place only outside the body, and after the blood has been drawn. There is no doubt that exflagellation is hastened by the withdrawal of blood from the body, but we have seen flagella bodies surrounded by phagocytes as soon as we could get the specimen under the microscope, and it is possible that the flagella may have been given out before the blood was drawn.

Manson speaking of the proneness to relapse in Malignant Tertian cases at page 66 says :—

> "After apparent recovery from the fever there is great proneness to relapse at more or less definite intervals of from 8 to 14 days."

It is important to distinguish between the Secondary fever or Flagellar fever, that has been described above, and a Relapse. A relapse conveys the idea of a repetition of the process that occurs in the original fever. The relapse in Enteric and in Relapsing fever are apparently a repetition of the original process, but the Flagellar fever is quite different from the Primary fever, for in the first place the Tertian nature of the fever is not so evident as it is in the Primary fever, and there is more frequently a rise of temperature daily, though not always, while it lasts, and in the second place, the examination of the blood shows that the parasites are in a very different condition from what they had been in the Primary fever. In the Primary fever we find the Ring forms, but in the Flagellar fever the Ring forms are only seen in small numbers, if seen at all. Then another great point of distinction is that at the end of the Primary fever we find Crescents, whereas at the end of the Secondary fever, we find that the Crescents have to a great extent, if not entirely, disappeared. The Crescent appears to be something like a chrysalis stage during which the flagella are developed, in the same way as the legs and wings of a mosquito are developed during the time that it is coiled up in the form to which the name 'nympha' is applied. Now if the Crescents are numerous at the beginning of the Flagellar fever, and if they are in small numbers at the end of it; if the degree of fever tallies with the number of flagella bodies to be seen in the blood, and certainly in the cases that we have examined, we have found that the higher the fever, the larger the number of Flagella that will be seen; if we find flagella bodies in freshly-drawn blood, then it would seem to indicate a strong probability at least that the exflagellation may occur in the blood before it is withdrawn from the human body, and to justify the introduction of the name which we have given to this particular stage of the fever, *viz.*, the " Flagellar fever. "

It is true, as most authors say, that we very rarely find exflagellated bodies in freshly-drawn blood, but we have seen hundreds of times, how the phagocytes have a special antipathy to the flagella bodies, and how they come swooping down from a considerable distance to envelop and destroy the flagella body as soon as it begins to throw out flagella, so if the phagocyte can thus by some marvellous instinct (if the expression may be used in such a sense) lay hold of the flagella body when it is placed at a disadvantage, by being pressed under the cover-glass, how much more likely is it, that the phagocyte would be able to catch the flagella body when it is free in the blood? If the flagella body is captured by the phagocyte before the blood is drawn, this may account for the fact that we seldom see exflagellated bodies in freshly-drawn blood.

It may be said that the phagocyte has a better opportunity of catching the flagella bodies when the blood is under the cover-glass, because the latter cannot move so easily as the former when they are in this position. The force of this argument must be admitted, and although we are not prepared to assert positively that exflagellation does take place within the body, still the arguments which have been given here, do seem to at least establish a probability that exflagellation may take place before the blood is drawn. At any rate we think that it is a point which deserves furthur consideration. Relapses do, however, occur at irregular intervals afterwards and in these the Ring forms are again found.

It is with some hesitation that we have ventured to advance this view regarding the occurrence of exflagellation within the body, because it is opposed to the view which Manson and others apparently hold. Manson says :—

> "It is important to bear in mind that they are never seen in newly-drawn blood, and that they come into view only after the slide has been mounted for some time—ten to thirty minutes, or even longer according to circumstances."

Manson's writings on Malaria are crammed full of facts,—facts so numerous that after some months of constant observations we are astonished not only by their accuracy but by their number, so in venturing to disagree with so high an authority on this point we do so with some hesitation.

It was on the 4th of January that one of the most intelligent of our observers, Ko Tha Aung, remarked that "you always find flagella in Crescent cases when fever comes on." Since that time we have examined many cases in order to test the truth of this statement, and we have found that there are three periods in a typical Malignant Tertian chart, and that each of these periods corresponds with a particular stage of the parasite.

There is first the Primary fever which may be a *clear* Tertian – that is, with fever on alternate days only—or with fever on the intervening days also. After the first day or two, each successive paroxysm is less than the preceding one, so that if the highest temperatures are joined by a line, this line nearly always shows a "downward slope"—a marked contrast with untreated cases of Benign Tertian and Quartan.

MALIGNANT TERTIAN CHART: NARHARI.

	February.																		March.							
Date ...	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7	8
Degrees of fever	**3**	**0**	**6**	**0**	**6**	**0**	**7**	**6**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**	**7**	**1**	**2**	**1**	**0**	**5**	**2**	**0**
Ring forms ...	2	2	0	2	5	25	34	34	6	14	9	5	3	0	0	0	0	1	3	0	0	0	0	0	0	0
Crescents ...	...	...	...	...	...	..	...	...	...	...	0	7	21	0	9	17	48	31	35	21	7	11	3	0	0	0
Flagella bodies ...	..	...	..	...	...	...	...	...	...	...	0	2	3	0	6	4	28	20	27	37	6	16	5	4	3	0
Rosettes ...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	...	3	0	...	...	...	...	...	...
	Primary fever period.										Crescent-forming interval.						Flagellar period.									

No. 88.—Narhari.

Date.	Number of specimen.	Hour when blood drawn.	Temperature.	Ring forms.	Rosettes.	Crescents.	Flagella bodies.
16-2-01	1	12-30 p.m.	95·0	25	..	..	..
17-2-01	1	4-30 p.m.	105·8	14	..	..	..
	2	4-36	105 8	2	.	..	..
	3	5-10	105·0	4	..	..	..
	4	6-10	104·0	3	..	..	..
	5	6-40	103·4	8	..	..	..
	6	7-11	103·4	3	..	..	
				34	.	..	..
18-2-01	1	9-15 a.m.	97·6	5	..	..	..
	2	9-45	97·0	2	.	..	..
	3	10-40	97·2	3	..	..	
	4	11-20	97·6	2	..	.	..
	5	12-15 p.m.	97·4	4	..	..	..
	6	1-0	96·0	3	..	..	..
	7	2-20	97·4	6	..	..	
	8	3-15	97·8	9	..	..	..
				34	..	..	..
19-2-01	1	10-30 a.m.	97·6	..	..	..	..
	2	11-10	98·6	1	..	..	..
	3	4-30 p.m.	103·6	5		..	..
	4	4-50	103·6	.	..	..	..
				6		..	
20-2 01	1	9-45 a.m.	98·2	3	..	..	..
	2	2-5 p.m.	97·6	7	..		..
	3	4-20	98·0	4	..	..	..
				14	..	..	..
21-2-01	1	11-50 a.m.	97·8	4	..	..	..
	2	2-15 p.m.	97·2	2	..	..	
	3	2-40	97·4	3		..	..
				9	..	..	
22-2 01	1	9-10 a.m.	98·0	4	..	..	..
	2	12	97·6	1	..	3	1
	3	6 p.m.	97·6	..	..	4	1
				5	..	**7**	**2**
23-2 01	1	8 10 a.m.	97·6	..	..	5	3
	2	12-35 p.m.	97·4	..	..	6	..
	3	4-35	97·6	3	..	10	..
				3	..	**21**	**3**
25-2-01	1	4 p.m.	97·6	..	..	2	3
	2	5-30	97·4	..	..	7	3
				..	..	**9**	**6**
26-2-01	1	8-8 a.m.	97·6	..	..	5	4
	2	9-30	97·0	..	..	12	..
				..	..	**17**	**4**
27-2-01	1	11 a.m.	98·	..	..	8	8
	2	12-20 p.m.	99·	..	..	23	13
	3	2-25	101·6	..	..	17	7
				..	..	**48**	**28**
28-2-01	1	9 a.m.	97·4	..	..	13	6
	2	11-45	97·0	1	..	18	14
				1	..	**31**	**20**
1-3-01	1	8-30 a.m.	98·2	..	..	10	1
	2	12-35 p.m.	99·8	1	1	11	6
	3	1-15	101·0	2	..	6	8
	4	3-20	104·2	..	2	8	12
				3	**3**	**35**	**27**
2-3-01	1	8-20 a.m.	98·2	..	..	5	16
	2	10	97·4	..	..	9	12
	3	2-15 p.m.	97·8	..	..	7	9
				..	..	**21**	**37**
3-3-01	1	9 a.m.	97·6	..	..	**7**	**6**
4-3-01	1	7-30 a.m.	99·	..	..	5	7
	2	1 p.m.	97·6	..	..	6	9
				..	..	**11**	**16**
5-3-01	1	9 a.m.	97·6	..	..	3	5
6-3-01	1	8-30 a.m.	98·8	..	..	..	4
7-3-01	1	12 a.m.	100·	..	..	..	4
9-3-01	1	12-26 p.m.	97·6	..	..	3	2
10-3-01	1	11 a.m.	98·0	..	..	2	3
11-3-01	1	7-20 a.m.	97·	..	..	3	..
12-3-01	1	11-30 a.m.	97·	..	..	3	2
13-3-01	1	8 a.m.	97·2	..	..	2	1

Duration of each examination 20 minutes.

2nd period—After the "downward slope" comes an interval of a few days during which there is little or no fever, and then comes the

3rd period—The Flagellar fever, which may have a Tertian appearance, but is not as "*clear*" a Tertian as the Primary fever as a rule, for we nearly always find some fever on the intervening days.

If we examine the parasites in these three stages, we find in the

1st period—Rings.

2nd period—A very marked diminution in the number of Ring forms, the Crescents gradually increasing, and at the end of it a few flagella bodies. In the

3rd period, we find Ring forms very rare; Crescents at first numerous and increasing, then decreasing and disappearing, almost if not entirely; flagella bodies increasing, decreasing, and finally disappearing.

The Primary fever is caused by the asexual sporulation of the Rosette forms; the interval occurs at the time when the Crescents are maturing; the Secondary fever then comes on, and although it is contrary to the view held by Manson, Ross, Christy, and others, still we believe that this part of the fever is caused by the breaking up of the Crescents, or in other words that exflagellation does occur inside the body. We cannot examine the blood before it is drawn, and therefore we cannot *see* whether exflagellation does occur before the blood is drawn, but by examining the blood daily and noting the changes that occur, we can draw inferences, and we would invite particular attention to the records of one case—the case of Narhari—and would ask whether any other reasonable explanation can be the highest during this part of the fever, and why? Was it due to the breaking up of Rosettes and the invasion of blood corpuscles by the spores? Or was it due to the exflagellation?

It is true that a small number of Rosettes and Ring forms were seen, but as we said above you always find a few green stalks in a ripe field of corn; it is also true that 150 flagella bodies were counted in the third stage while only four Ring forms were found, and that 110 Ring forms were found in the Primary fever and not one flagella body was found. If the Secondary fever was not due to some different process from that which took place in the Primary fever, how can the alteration in the condition of the parasites which were observed be explained?

Subsequent Notes.—There is one strong objection to the view that exflagellation takes place inside the body, *viz.*, that there is not any evidence that the parasites breed sexually inside the body. For if, as an American writer puts, there are no half joints in nature, it is not likely that this part of the sexual process would take place inside the body. There is no doubt, however, that the Crescents are in some way broken up inside the body, and perhaps the words " broken up" should be substituted for "exflagellation" and converted into " flagella bodies."

Professor Wright, writing from Netley on 25th April 1902, says :—

> "The Flagellar fever theory and internal flagellation seem to me very likely. We have been watching a case here in the light of your theory, and it has conformed in all points with it..........Please make use of any passage in this letter you wish to quote."

In Part II will be found a number of other observations bearing on this theory.

CHAPTER IX

MALIGNANT TERTIAN CHARTS

QUARTAN charts and Benign Tertian charts can be easily placed in groups for the purposes of description, but when we attempt to classify the Malignant Tertian charts we are met with some difficulties, for they present great variety. There are some that might be called clear Tertians, that is, with fever on one day and no fever on the next, and there are others in which we find fever every day, but with fever a little higher on alternate days. We propose, however, to follow a different system of classification, but at the outset we must make it clear that the different groups do not represent any inherent differences in the parasites, but rather different degrees of severity or different stages in the fever.

We have said that the Malignant Tertian chart often shows the following stages :—(1) the downward slope ; (2) the crescent-forming interval ; (3) the Flagellar fever period. All charts do not, however, show these three periods, for some only show the downward slope, and there are some which show only the Secondary fever, that is, in the case of men who did not come to hospital when they were first attacked. Then there are some which show a relapse or a fresh onset of fever coming some time after the Flagellar fever.

We propose then to illustrate the Malignant Tertian fever by giving—

(1) Charts showing the downward slope only.

(2) Charts showing the downward slope, the crescent-forming interval and the Flagellar fever.

(3) Charts showing the Flagellar fever at the time of admission.

(4) Charts showing a relapse.

(5) Irregular cases.

The number of cases that have been thus classified is 46. It may be said that it is not advisable to draw definite conclusions from such a small number, but as quinine had not been given to these cases for some time after their admission, and as it would not be advisable to withhold quinine from a large number, the natural course of the fever can perhaps best be studied from observations that have been made on small numbers. It ought, however, to be mentioned that these cases were observed in the winter months, and at this season malarial fevers are much milder on the whole than those which are met with in the months of September and October.

Cases to illustrate the downward slope:—

Case I—Chitsoon. This chart shows the higher temperatures on the 8th, 10th, 12th, &c., and it also shows a slight rise of temperature in the intervening days at first. It shows also that the temperature does not fall to the normal in the intervening days. Celli remarks at page 46:—

> "This form of Tertian is also called Malignant inasmuch as it may become Malignant, the paroxysms being prolonged and approaching one another till it simulates a continued fever and become subcontinued."

ABSTRACT OF MALIGNANT TERTIAN CHART.

CASE I.—CHITSOON.

December.

Celli further remarks that "it is also called Æstivo-autumnal Tertian, because it is observed only in the summer and autumn, never in the spring." By far the larger number of cases of fever admitted into this hospital during the months of January and February were of the Malignant Tertian variety, so the name æstivo-autumnal should be used with a certain amount of reservation.

On the 18th of December, that is eleven days after admission to hospital, and on the thirteenth day of the disease, twelve Crescents were seen in one slide in a few minutes. On the 26th December only one Crescent was found. On the 6th January nothing was found. Manson (page 16) says "the Crescent body does not begin to show itself till it approaches maturity—about a week after the first crop of amœboid parasites associated with the fever paroxysm has appeared."

Case II—Sheoram. The next chart, which is taken to show the gradual slope of temperature, is that of Sheoram. Crescents were found on the fifteenth day. His blood had not been examined however for a week, so it is probable that Crescents appeared earlier.

CASE II.—SHEORAM.

	December.						January.									
Day of disease	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10
Day of fever ...	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Degrees of fever	**3**	**3**	**0**	**5**	**1**	**4**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	[illegible]	

NOTE.—On the 29th, 31st and 3rd, 5, 4, 3 degrees of fever.

Case III—Seetia. The next group of charts shows the gradual slope downwards, an interval of slight or no fever, and then the Secondary fever. To illustrate this group, we may take first the chart of Seetia. Note the apparent change of day of the fever. At first it came on the 23rd and 25th, then it began to come on the even days 26th, 28th, &c.

CASE III.—SEETIA.

	December.									January.														
Date ...	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	1
Day of disease	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	2
Degrees of fever	**6**	**4**	**6**	**5**	**3**	**4**	**2**	**3**	**1**	**2**	**0**	**1**	**1**	**4**	**0**	**4**	**2**	**2**	**1**	**0**	**0**	**0**	**0**

NOTE.—On 4th, 6th, 8th, 10th, 5, 4, 3, 2 degrees of fever.

On the 4th January, the thirteenth day of the fever, about a dozen Crescents were seen, and on the same day flagella bodies were seen. The Secondary fever lasts for about a week; it is irregular but presents some appearance of Tertian.

On the 13th January, that is the 22nd day of the disease, nothing was found in the blood. This is the usual course, for Crescents are not found in large numbers after the Secondary fever disappears. Now if this fever, which we have called the Secondary fever were a relapse, then we should expect to get Crescents after it, as we do after the primary fever. But in some dozens of cases we find the same sequence of events—the gradual slope, the interval of no fever or of little fever when many Crescents are found, the Secondary fever in which flagella are seen, and then the disappearance of fever, while at the same time the Crescents and flagella disappear from the blood, at least from the peripheral blood.

At first we were not able to prove that the Malignant Tertian parasite can be conveyed by the anopheles, and we thought that this might be due to the fact that care had not been taken to allow the mosquitoes to bite when the flagella bodies were present. Experiments were then made with mosquitoes which were allowed to bite a man during the flagellar period. These will be described later.

CASE IV.—MOHAN.

		December.			January.				
Date ...	25 26	27 28	29 30	31 1	2 3	4 5	6 7	8 9
Day of disease	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16
Degrees of fever	**5 0**	**5 0**	**2 0**	**0 0**	**0 3**	**2 6**	**2 2**	**0 0**

Case IV—Mohan. This chart illustrates the downward slope, the Crescent interval and the Flagellar fever. On the eighth day two Crescents were seen. On the tenth day many Crescents and flagella bodies were seen. On the eleventh day flagella were seen. On the 26th day, although he had no fever, his blood was examined as discharged Crescent cases were from time to time examined. Colonel Poynder, I.M.S., happened to be here at the time, and he made the following note in regard to the flagella body :—

> " Cell full of actively moving grains of pigment with a clear space externally; shortly some of the grains of pigment moved out into the clear space having devoloped flagella and whisked about actively. A short distance away in the field was a phagocyte which suddenly swooped down on the scene of action—rapidly enveloping the whole cell and the moving flagella. Within a few moments, movement had stopped and the pigment gradually became smaller and the phagocyte more finely granular in appearance."

On the 23rd January, Mohan had fever, and ring forms were seen again.

Malignant Tertian Charts—Group III.

Case V—Ramjia. The next group of charts are chosen to indicate the Flagellar fever at the time of admission to hospital. Some of these cases had been in hospital previously and some may have had slight fever without coming to hospital for treatment. This group is a purely artificial group, for they do not represent a different kind of fever, but by putting them in a separate group we wish to draw attention to the importance of recognizing the Flagellar fever. For instance, the first chart given here is that of Ramjia. He had been in hospital from the 3rd till the 11th of December, and he had been discharged before the time when

CASE V.—RAMJIA.

	December.									
Date ...	16	17	18	19	20	21	22	23	24	25
Day of disease ...	5	6	7	8	9	10	11	12	13	14
Degrees of fever ...	**5**	**0**	**4**	**0**	**4**	**0**	**0**	**1**	**1**	**1**

we had discovered the Flagellar fever. He came back to hospital on the 16th of December, and the chart given here shows particulars of his case after that date.

16th—(that is the date of second admission). Crescents were found in his blood.

17th—Many Crescents and some flagella seen by Dr. Agnes Henderson.

19th—Twelve Crescents seen in about two minutes. Four Crescents seen in one field : flagella also seen.

25th—Discharged from hospital.

26th—Four Crescents seen in 10 minutes' examination.

This case illustrates the importance of the recognition of the Flagellar fever, for the man was discharged from hospital before the onset of this fever and he had to come back to hospital again. We may be asked to say whether an officer who wishes to go on tour in his district can safely go after he has apparently recovered from an attack of fever. If he had been suffering from a Quartan it would be perfectly safe to give permission to go, but if the fever from which he had recovered were the primary part of a Malignant Tertian, then the possibility of the occurrence of Flagellar fever would have to be considered.

CASE VI.—PAIKAN.

	December.							
Date ...	16	17	18	19	20	21	22	23
Day of disease ...	2	3	4	5	6	7	8	9
Degrees of fever ...	5	1	0	1	0	1	0	1

Case VI—Malignant Tertian. Paikan had not been in hospital before, but he said he had had fever six days before he came to hospital. On the day of admission his temperature was over 103. Many specimens of his blood were examined on this day, and many flagella bodies were seen, but only one Crescent was found.

19th—One Crescent seen after a long search; phagocytes have much pigment; flagella bodies seen.

26th—No Crescents seen in 5 minutes' search.

The history of previous fever, the finding of flagella and Crescents on the day of admission, and the absence of Crescents at the end of the fever show clearly that the man was admitted when he was suffering from the Flagellar fever.

Two Crescents were found on the 9th January.

MALIGNANT TERTIAN—GROUP IV.

Case VII—Ramia. The chart of Ramia will be given to illustrate the fact that in Malignant Tertians we sometimes have a chart which presents a clear Tertian appearance, resembling in appearance the chart of a Benign Tertian.

CASE VII.—RAMIA.

	February.											
Date ...	1	2	3	4	5	6	7	8	9	10	11	12
Day of disease ...	1	2	3	4	5	6	7	8	9	10	11	12
Degrees of fever ...	**5**	**0**	**5**	**0**	**4**	**0**	**6**	**0**	**4**	**0**	**2**	**0**

MALIGNANT TERTIAN—GROUP V.

It might be expected that we ought to be able to dispose of all the charts in the groups that have been already described, but unfortunately this is not the case. There are some charts which show an attack of fever coming several weeks after the first attack, and these present such a great variety that it would be impossible to make them fit into any typical group.

Subsequent Note—May 1902.—A large number of observations have since been made. The "Downward slope" referred to here is not always found. We often see an upward tendency for the first few days and then a gradual fall of temperature.

CHAPTER X.

AN ATTEMPT TO RECONCILE THE VARIOUS VIEWS REGARDING MALIGNANT TERTIAN FEVER.

THE literature on Malignant Tertian fever is rather confusing, for we find authors making statements which are widely at variance. It may be useful to consider whether a knowledge of the fact that there are more or less definite periods during which particular forms of parasites are seen, will help us to reconcile what appear to be directly contradictory statements. Some extracts from the writings of various authors will be given below in order to show to what extent they differ. Special prominence will be given to the views of Drs. Stephens and Christophers, who have recently written a Report on "The Malarial Infection of Native Children" in Lagos on the West Coast of Africa, because it would seem that their observations, to a large extent, substantiate what we have observed here, and because the conclusions which they have drawn and the theories they have advanced do not appear to be justified by the observations they have recorded. Their paper is published in the Royal Society's "Reports to the Malarial Committee," third series. Unfortunately, in the tables which are published with their paper, they do not make any distinction between the Crescent and the flagella bodies, but classify them all together under the heading "gametes," and they do not give charts of the cases, nor mention the temperatures of those in which "*gametes*" were found, nor say whether there was any difference in the temperatures when flagella bodies were found. But they do mention, at page 9, that " contrary to our expectation there is a sequence in the occurrence of parasites." Now, everybody knows, and Manson and Celli have distinctly pointed out, that there is a *sequence* from Ring forms to Crescents, and Stephens and Christophers were evidently aware of this, for they say, in an earlier part of their paper, " While in European blood, subsequent to an attack of fever it is the crescentic form of the gamete that is encountered," &c. What they evidently meant to convey is that there is an " alternation," for they quote cases to show that they sometimes found asexual parasites, followed by gametes, and others in which they found gametes followed by asexual forms. The cases that we have met with here have been divided into five groups, *viz.*:—

(1) Those showing the Primary fever without Flagellar fever.
(2) Those showing the Primary fever and the Flagellar fever.
(3) Those showing the Flagellar fever only—they are cases that had not come to hospital during the Primary fever.
(4) Those showing true relapses, that is, cases showing the Primary fever, the Flagellar fever, and afterwards a true relapse in which Ring forms are again found.
(5) Irregular cases in which many Ring forms and flagella bodies are found at the same time.

The cases recorded by Stephens and Christophers in their Tables would fit into these groups fairly well.

For instance their case 9: many parasites in the 2nd half of July: only one gamete seen in August (10th), would probably fit in with our Group I; their Case No. VII of Table II showing 5 asexual parasites on the 4th of August and 7 gametes on the 12th August would probably fit in with our Group IV.

Of course, as said above, they have not given the temperature charts and they have not made any distinction between the Crescents and flagella bodies in their tables, but the results of the blood examinations show such a strong resemblance to those which we have found here, that it would seem as if there is a great similarity between the Malignant Tertian of Lagos and the Malignant Tertian which we find here.

When we come to consider the question whether the Crescent changes into the flagella body before the blood is drawn from the body we find the opinions of writers as follows :—

Manson at page 13 says : —

> "It is of importance to bear in mind that they (flagellated bodies) are never seen in newly-drawn blood and that they come into view only after the slide has been mounted for some time—10 to 30 minutes."

Ross—West African Report, says :—

> "They remain unchanged within the vertebrate hosts.

Christy—page 3 :—

> "The fact that the flagellated body did not come into existence until the blood left the vessels and was outside the human body," &c.

Celli—page 48 :—

> "In the human body they (Crescents) appeared to be and in fact are sterile."

Manson is of opinion that flagella bodies are never seen in freshly-drawn blood, and the authors mentioned above agree with him.

Stephens and Christophers, however, at page 5 of the Report mentioned above, say :—

> "It is here that Native blood presents many points of divergence from European blood—features that have hitherto not been recorded. While in European blood subsequent to an attack of fever it is the crescentic form of the gamete that is encountered, in Native blood while gametes are exceedingly common, yet the crescentic form is rare, the gametes assuming the spherical forms found in simple tertians and quartans. .... We are convinced on the contrary that the crescentic form is not an essential distinctive feature of the æstivo-autumnal parsite."

Stephens and Christophers having found what Manson, Ross and Celli say never occurs, proceed to give an explanation. Now there are two ways in which the difference in the observations might be explained—one that Native blood is different from European blood, the other that the specimens of blood may have been examined at different periods of the disease. Stephens and Christophers do not apparently take the latter into consideration ; without bringing forward any argument or assigning any reason for the conclusion they have drawn, they say that there are many points of divergence between Native and European bloods, and they do not make the suggestion that the difference in the observations may possibly be accounted for by the observations having been made at different stages of the attack.

We have seen a good many cases of malaria in Natives of India and in Europeans, and the symptoms seem to be exactly the same in both, and as far as we can judge from the descriptions given of the parasites by Manson and Celli the parasites seen here and those seen in other parts of the world seem to be the same, excepting in some minor points, which may possibly be due to differences in description. We have seen, however, that there is a period when more Crescents are found than flagella bodies and there is a period when the flagella bodies are more numerous than the Crescents, and until Stephens and Christophers have examined a number of cases throughout their whole course we must hesitate to accept their statement that the Crescent does not occur in the æstivo-autumnal fever.

The next question to consider is whether there is any connexion between the Crescent body or flagella body and relapses, and we may take relapse here to include Secondary fever from whatever cause.

Manson (page 66) says "the Crescent body does not cause fever." Celli (page 52) says "so that Golgi erroneously believed that these Crescents represented the germ of recurrent fevers." Stephens and Christophers (page 9) "We cannot in the present state of our knowledge, attribute any part to the gametes in the production of relapses ;" but in the same page, and a few lines above, these writers say :—

> " So that it would appear as if there was a succession of gametes, in the same way as we have a succession of developments of asexual parasites leading to the ordinary febrile attacks of Europeans "

What is meant by this last paragraph is not clear. Do they believe that one gamete (Crescent) produces another gamete without going through the regular stages of Ring form, Crescent, flagellate body ? If so, they do not bring forward any arguments to support this view.

They have been puzzled by what they have seen, but it is perfectly clear that they have been examining cases during the Flagellar fever period.

We believe then that we have shown that many of the differences of opinion which exist at present will disappear when it is recognised that there are two fever periods in the Malignant Tertian, and if writers on the subject will take care to particularise what period of the fever they are describing.

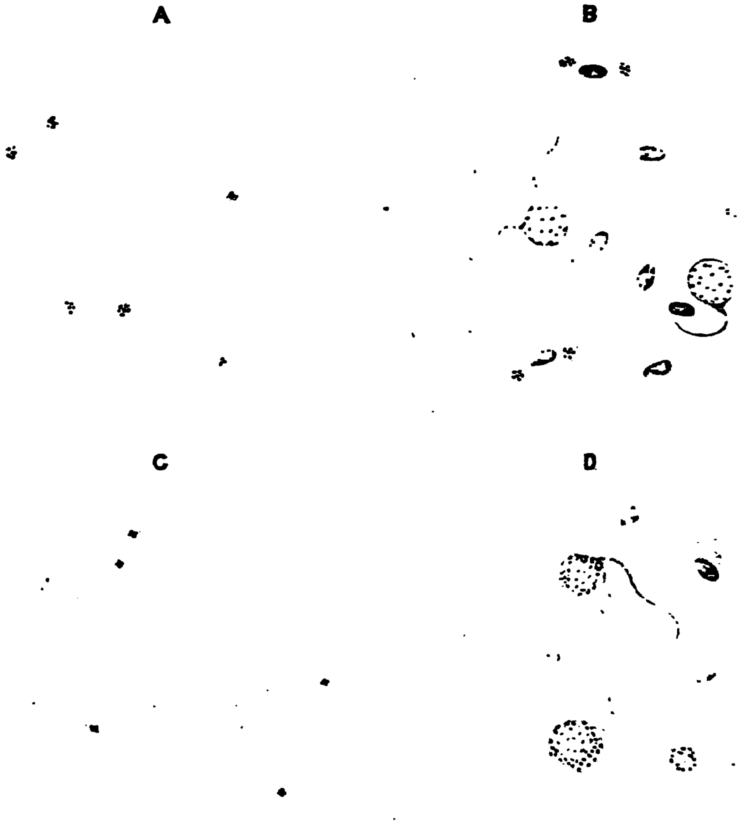
In Manson, at page 66, we find :—

> "A. Plehn states that during a period of two years' residence in Africa he only once saw the flagellated body"

and is it not curious that Stephens and Christophers should have found it so frequently?

SPARROW MALARIA PARASITES.

PLATE VIII.



A. Quartan parasites: Halteridium.
B. Ditto Flagella bodies.
C. Tertian parasites: Proteosoma: note how the nucleus is shoved aside.
D. Ditto Flagella bodies and a free flagellum.

CHAPTER XI.

MALARIA IN SPARROWS.

Two kinds of parasite have been found in sparrows—one called the proteosoma, which is round in shape, and the other halteridium, because it was supposed to resemble a halter. In the investigations which have been made here it has been found that those sparrows which have the proteosoma in their blood get a rise of temperature every other day or Tertian fever, and those which have the halteridium in their blood get a rise of temperature every third day or Quartan fever.

The observations which led to the discovery of the fact that sparrows get Tertian and Quartan fever were made during the months of March, April, May, June, July and August, and during these months there were a few admissions of men to hospital for Tertian and Quartan fevers. This seemed rather curious, and the question was asked whether the parasites which cause Quartan in sparrows are the same as those which cause Quartan in man, and are the Tertain parasites of sparrows the same as the Tertian parasites of man ? If there is any truth in the statement which is now accepted by many writers on Malaria in regard to the conveyance of malaria parasites from man to man by means of mosquitoes, then it would be important to enquire whether parasites might be conveyed from birds to man.

In the Lecture on Malaria, which Professor Koch delivered at Eastbourne, on the 26th July 1901, he said, when speaking of the measure proposed by him for extermining malaria, that "in making this proposal I presuppose two things—firstly, that the malaria parasites are restricted to man. As to the first of these proposals I regard it as adequately proved by the fact that nobody has yet succeeded in finding parasites identical with the human malaria parasite in the blood of any animal."

A few days before Koch had delivered this Lecture, he had in his Lecture at the Tuberculosis Congress given his reasons for thinking that the bacillus of bovine tuberculosis was not the same as the bacillus of human tuberculosis. It is well known that bacilli alter in many respects according to their environment and as it is now looked on as a matter of the very greatest importance to decide whether the tubercle of man is the same as the tubercle of cattle, so from the point of view of prevention it is also important to enquire whether the malarial germ of man is the same or is in any way related to that of animals or birds.

Koch presupposes that the malaria parasites of man are restricted to man, and he bases his principal method of prevention on this assumption. The malaria parasites of the sparrow differ considerably in appearance from those of man, but this might be expected from the fact that the blood of birds differs so much from that of man. Are the differences which have been observed between the human and bird parasites due to environment merely, or are the parasites totally different? It was with a view to throwing some light on this subject that the investigations regarding sparrow malaria have been made.

Altogether 292 sparrows were examined. Their temperatures were taken twice daily and entered in charts. Each blood examination lasted 5 minutes and the number and kind of parasites found were entered in the charts. The effect of quinine given by mouth as well as hypodermically was watched in some cases and the effect of methylene blue in others. In the table given below is shown the number of sparrows examined in each month, the number in which Quartan parasites were found, the number in which Tertian parasites were found, the number with both kinds of parasite, and the number in which no parasites were found. The percentage of the whole number in which parasites were found is also noted.

Table showing the number of sparrows examined.

Month.	Quartan.	Tertian.	Double infection.	No. of sparrows without parasites.	Total.	Per centage in which Parasites found.
March 1901	4	10	13	7	34	79
April ,,	26	22	2	17	67	75
May ,,	17	6	0	71	94	24
June ,,	10	1	1	32	44	27
July ,,	18	0	0	5	23	78
August ,,	26	0	0	4	30	87
	101	39	16	136	292	

This table shows that the percentage of sparrows having parasites in their blood in March and April was 75, and in the two following months it was about 25. In the months of May and June malaria fevers in man are at their minimum, and it is worthy of notice that the numbers of sparrows infected in these two months appears to be less.

Second, it is also worthy of notice that the proportion of Tertian parasites found in May and June decreased considerably, and this would suggest the possibility that the agency by which the Tertian is conveyed to birds may differ from that by which the Quartan is conveyed. In the experiments which were made here regarding human malaria we were not able after many experiments to convey Quartan from man to man by means of anopheles although there was evidence in favour of the Benign tertian having thus been conveyed.

Third, Dr. Lawrie, of Hyderabad fame, has written in the *Indian Medical Gazette* regarding sparrow malaria, and he has made a number of statements which we have over and over again proved to be wrong, such as that the halteridium and the proteosoma are the same and that the parasites are not affected by quinine. Dr. Lawrie's paper will be dealt with separately, but it has occurred to us that if he was examining the sparrows at a time when the Tertian parasites are not found, then it would be easy to understand how he made such a great mistake in saying that sparrow parasites are not affected by quinine. The Tertian parasite is undoubtedly affected by quinine, but the Quartan is only slightly affected by it.

While carrying out these observations we noticed that those sparrows which had the long parasite (halteridium) in their blood had higher temperatures every third day, that is, they had Quartan fever. This was noticed in nearly every case—101 altogether. The temperatures of some of these sparrows were taken for as many as 60 days, and throughout the whole time the chart showed the Quartan appearance. Similarly most of the 39 with the round parasites showed a Tertian appearance in the charts, and those in which no parasites were found never showed either a Quartan nor a Tertian appearance in their charts. After the administration of quinine to those which had the Tertian parasites the Tertian appearance of chart disappeared if the quinine was given in sufficiently large doses, affording good evidence that the fever was due to these parasites.

In 16, both the Tertian and Quartan parasites were found together, and in these the fever was, as a rule, somewhat irregular.

NORMAL TEMPERATURE OF SPARROWS.

Charts were kept of a number of sparrows in which no parasites were found, and these showed that the temperature was usually about 103 in the morning and 106 in the evening.

QUARTAN FEVER IN SPARROWS.

In the Quartan of man we have often seen that the temperature on the three successive days is "high," "low," "lower," that is, on the first day it is high, next day it is not so high, but often a little above normal, and on the third day it is normal; and it is a curious thing that in sparrows we nearly always find the temperature on the second day of each period lower

No. 95 SPARROW: QUARTAN CHART.

	May.																					
Date	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Degrees of fever	**3**	**5**	**3**	**3**	**5**	**3**	**3**	**4**	**3**	**2**	**5**	**2**	**3**	**4**	**2**	**1**	**3**	**2**	**2**	**4**	**2**	**2**
Pigmented parasites	226	207	253	Not examined.	252	225	239	243	224	...	250	229	233	...	...	...	179	187	185	191	187	173
Flagella bodies	32	95	86		95	59	42	65	40	...	93	72	62	...	...	...	35	29	39	57	35	22
Rosettes	...	...	...		...	...	...	...	...	...	...	...	...	...	...	...	.	...	...	...	...	...

No. 89 SPARROW: QUARTAN CHART.

	April.		May.																					
Date	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Degrees of fever ...	**3**	**3**	**2**	**2**	**4**	**3**	**2**	**4**	**2**	**2**	**4**	**3**	**1**	**4**	**3**	**3**	**4**	**3**	**2**	**3**	**2**	**2**	**3**	**2**	**2**
Pigmented parasites ...	19	25	19	...	22	19	...	20	...	39	45	41	...	37	...	33	42	34	...	...	...	15	14	11	12
Flagella bodies ...	9	13	12	...	14	6	...	15	..	23	39	28	...	32	...	19	25	17	...	...	...	8	4	3	1
Rosettes	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

than the first day temperature, but not so low as the third day temperature. This "high," "low," "lower" temperature applies to each successive cycle of development of the parasites.

The Quartan parasites of the sparrow resemble the Quartan of man in having large granules of pigment and in their slow movement, but they differ in the following points :—

(1) They do not fill the whole red blood corpuscle, but lie along one side of the corpuscle, half surrounding the nucleus.

(2) The Rosettes are very seldom* seen in the sparrow, but flagella are seen very often, while in man flagella are rarely seen, but Rosettes can always be found in the shivering stage. The exflagellation can be seen in almost every field in some cases. We have frequently put specimens of blood under the microscope as quickly as possible after the blood was drawn in order to see whether it is likely that exflagellation has taken place inside the body.

SPARROW TERTIAN.

We have before us as we write the charts of 28 sparrows, in which Tertian parasites were found, and in which the chart shows Tertian fever. The temperatures are frequently about 108° or 109° on one day and 106° or 107° on the next day. In the human Benign Tertian fever we have noticed that there is frequently a change of day in the fever, that is, if the days for fever are the 2nd, 4th, 6th, &c., we may see the fever coming on on the 9th, 11th, 13th, &c., and it is a curious fact that a similar change of day is noticed in the case of sparrow Tertian.

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* See note at end of this chapter.

TERTIAN PARASITES.

These have been called proteosoma. They are round and rather small, usually placed at one end of the corpuscle and they nearly always push the nucleus of the corpuscle to one side. A Quartan parasite grows along one side of the nucleus but never dislocates it as the Tertian does. In the Tertian the pigment is fine, and the Rosette has about 20 parts.

EFFECT OF QUININE.

Dr. Lawrie of Hyderabad has said that quinine has no effect on the malarial germs in sparrows. He probably did not experiment on sparrows with Tertian parasites, for quinine has a most wonderful effect on these parasites and on the Tertian fever. If we take a few charts we shall see the effect of quinine.

In the abstracts of the Charts 106°F. is taken as the normal evening temperature and the figures in the column for degrees of fever indicate the number of degrees above 106, thus the figure 3 indicates a temperature of 109°.

Case (1), *Sparrow No.* 56.—Here we see between the 6th and 26th April 11 paroxysms, in which the temperatures on alternate days went up to 108° or 109°. On the 27th one grain of quinine was given by mouth. From the 28th till the 5th May the temperature was not above 106°. The number of parasites seen in a five minutes' count had been 15 : 10 : 15 : 8 : 12 : 5 : 9 : 3 : 5 : 13 : before the quinine was given. The next counts were made on the 3rd, 4th, 5th and 6th

SPARROW No. 56: (TERTIAN) CHART.

	April.																									May.		
Date ...	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	23	27*	82	29	30	1	2	3
Degrees of fever ...	2	1	3	1	2	1	3	1	3	1	2	1	3	1	2	0	2	0	2	0	1	0	0	0	0	0	0	0
Pigmented parasites ...	3	2	2	1	3	2	6	..	7	5	10	7	10	6	7	4	5	2	3	...	10	...	...		0	0	0	0
Flagella bodies ...	0	0	0	0	0	0	6	...	1	1	2	2	2	1	2	1	2	1	1	...	3	..	...		0	0	0	0
Rosettes ...			...		...	0	0	0	0	0	3	1	3	1	3	0	2	0	1	...	2	...	...		0	0	0	0

* One grain quinine by mouth.

SPARROW No. 58: (TERTIAN) CHART.

	April.																									May.			
Date ...	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23*	24	25	26	27†	28	29	30	1	2	3	4
Degrees of fever ...	2	0	2	1	3	2	1	2	0	1	0	2	0	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Pigmented parasites...	2	1	1	3	2	3	2	...	4	7	8	5	3	2	1	5	3	8	6	...	5	0	0	0	0	0	0	...	...
Flagella bodies ...	0	0	1	0	0	0	0	...	1	2	1	2	1	0	0	3	2	1	3	...	2	2	0	0	0	0	0	..	..
Rossettes ...	0	0	1	0	0	1	1	...	1	1	1	1	1	1	2	2	1	2	1	...	3	..	0	0	0	0	0	...	...

* Half grain quinine by mouth.

† One grain quinine by mouth.

days after quinine was given and not a single parasite was seen.

Case (2), *Sparrow No.* 58.—In this case there were nine paroxysms before quinine was given. The paroxysms came on the even days at first—6th, 8th, 10th—and then came on the odd days—11th, 13th, &c. Half a grain of quinine was given by mouth on the 23rd and one grain was given on the 27th. The temperature, which had been 107, 108 or 109 on alternate days, did not go above 106 for a fortnight. The parasites were not appreciably reduced in numbers after the half grain, but after the grain was given no parasites were seen for five days. There had been from 3 to 11 seen daily before the quinine was given. The chart after this again shows a distinctly Tertian type and parasites were again found.

Case (3), *Sparrow No.* 36.—After six paroxysms, in which the temperature on alternate days was 108°, half a grain of quinine was given. One paroxysm followed and the number of parasites was not appreciably diminished. One grain was given by mouth and after that no parasites were found and the temperature did not again go above 106°.

Case (4), *Sparrow No.* 67.—Tertian fever up to 108° and 109°. After one grain of quinine the temperature remained below 106° for six days Before giving the quinine, 32 parasites were counted in five minutes. On the day following the administration of quinine no parasites were found. A few days later the chart shows distinct Tertian and from 13 to 56 parasites were found in the five minutes search.

Case (5).—In this case the temperature was 109. One-fifth grain of quinine was given hypodermically

Nine parasites had been seen on the day before the quinine was given. Next day four were seen, and in the following nine days only one was seen. Then parasites were again seen and the chart again showed a Tertian appearance. One grain of quinine was then given by mouth. The parasites disappeared, and, in the next four days, none were found. The temperature during this time only went above 106 on one day.

The above cases are a few that have been taken at random from a large number, but they are sufficient to show the very marked influence of quinine on the Tertian parasites and fever in sparrows.

We have seen then that at a time of the year when we have been finding Quartan and Benign Tertian parasites in men we have found Quartan and Tertian parasites in sparrows; that the parasites of sparrows in many respects resemble those of man; that the special peculiarity of the Quartan in man, the "high," "low," "lower," temperature is also well seen in sparrows; that the special peculiarity of the Benign Tertian in man, the tendency to change of day is also well seen in sparrows; that quinine has a marked effect on the Tertian of sparrows; that there are usually about ten spores in a human Quartan, and there are about eight in a sparrow Quartan, and that there are about twenty in a human Tertian, and about the same number in a sparrow Tertian. We have seen here in the Central Provinces very often that the worst cases of fever are found in men who have been working or "shikarring" in the jungles far away from human habitation, and if malarial fever is conveyed from man to man, and from man to man only, how can the excessive severity in such cases be explained?

We do not say that the malaria of sparrows is the same as that of man; but we would ask, is Professor Koch justified in making the pre-supposition that the malaria of man is confined to man and in basing a line of preventive treatment on this assumption before he has proved that the parasites of man are not the same as those of birds or other animals.

Subsequent Note.—(1) We are doubtful if Rosettes are found in the Quartan of sparrows. Notice the large number of flagella bodies seen in the Quartan cases on the day of fever. If Rosettes are not found, and if flagella bodies are more numerous on the day of fever, how far does this tend to confirm the idea that there is a relationship between the ripeness for exflagellation and the Secondary fever in Malignant Tertian (human)?

CHAPTER XII.

THE ANTI-PLASMODISTS.

THERE are two sides to every question, and while some observers consider that the parasites are the cause of the malarial fevers, there are others who take a contrary view and who do not believe that the small bodies which have been described are parasites at all and that they have nothing to do with the fever. Chief among these is Dr. Lawrie, and it may be worth while to consider the arguments which he has brought forward to prove that these small bodies are not parasites. Dr. Lawrie has written that "the points of controversy between ourselves and the plasmodists cannot be settled by mere assertion and counter assertion," and we shall enquire whether and to what extent some of the assertions are based on facts.

We have examined about 300 sparrows in the past few months. Two or three men have been employed taking the temperatures under the wing, and four others have been examining the blood of these sparrows daily. The temperatures have been entered in charts, and at the foot of the charts the number and kind of parasites seen at each examination have been recorded. There were very few exceptions to the rule that where we found the halteridium we saw a Quartan chart, where we found the proteosoma we found a Tertian chart, and where we found no parasites we found neither a Quartan nor a Tertian chart. The exceptions were a few cases, in which the observations were not continued long enough owing to escape or death of sparrows. When then Dr. Lawrie says that the two parasites are the same, is making one of those assertions which he so strongly deprecates.

In the paper which appeared in the *Indian Medical Gazette* in November 1899, Dr. Lawrie said that " the only difference between the proteosoma and the halteridium is that the halteridium is halter-shaped and the proteosoma is round," and in the same paper he says :—"Some remain circular for some time, and somewhat resemble the hyaline bodies seen in human malarial blood. Others soon appear to have a constriction in the centre and contain a few black granules. Most of them become halter-shaped when they attain the full size."

In the sparrows which we have examined, if we found round forms at the beginning in the blood cells, we found them throughout the examinations, which lasted for some weeks, and if we found the long parasites (halteridium) we also found them throughout. When either parasite is free in the plasma it may be round, but while they are within the red blood cells they are perfectly distinct.

Dr. Lawrie then says :—

"Several pigeons were given quinine hypodermically and by the mouth, but without any effect in reducing the numbers of the proteosoma." It is not stated how much quinine was given. We have been told that Quartan fever is not much influenced by quinine and on enquiry have been told that only small doses were given, but we have never seen a Quartan fever which has not been stopped for a time by one dose of twenty grains of quinine. No conclusion of any value can therefore be drawn from the fact that quinine was administered to birds unless the quantity of quinine is known. We have found that one grain of quinine given by mouth to sparrows has a very marked effect in reducing the number of parasites.

We shall next deal with a number of conclusions that have been come to at Hyderabad. It is stated that no form of Laveran body, either human or avian, is a parasite, and as it fulfils none of Koch's canons, it cannot be "pathogenic."

The first of Koch's canons is, "the microbe in question must be found in the blood and tissues of the animal which has suffered from the disease." We have found the Quartan parasite in every case in which we have seen Quartan fever; we have not seen the Quartan parasite in any case in which the chart did not show Quartan fever; we have allowed the cases to go for some time for the sake of observing them, and have examined them hundreds and hundreds of times, and we have seen that the parasites are always present while the fever lasts; when a patient comes into Hospital, if Quartan parasites are seen, this is noted on his ticket, and we have been able in every case to predict from an examination of the parasites that the chart would have a Quartan appearance; we have been able very often to say on what day the fever would come by the appearance of the parasites; we have seen in every case that when the shivering begins Rosettes will be found in the blood; and we would ask then is there any other germ which has been credited with the causation of any disease which more thoroughly fulfils

Koch's first canon than the parasite which causes Quartan fever? Further, we have seen how when quinine (twenty grains) is given the parasite of Quartan disappears* and how the fever stops at the same time. And yet we have Dr. Lawrie's assertion that these parasites or Laveran's bodies do not fulfil one of Koch's canons.

There is one of Koch's canons that they do not fulfil, *viz.*, that the germ must be translated from culture to culture for several generations, taking precautions against the introduction of other microbes. But here may it not be Koch's canons that are at fault, for although there are many microbes which can be isolated and cultivated for several generations a difficulty arises when we have to deal with the intracellular microbes.

The third of Koch's canons is that the microbe must be capable of causing the disease in a healthy animal. Manson's and Fearnside's experiments in transferring Benign Tertian fever from one individual to another are sufficient to convince most people on this point.

Dr. Lawrie next makes the extraordinary assertion that "neither the plasmodium nor the proteosoma possesses the function of reproduction." The men who are working in this Laboratory smiled when they read this "*assertion*" for they have, night after night, put parasites under the microscope, kept them warm near a lamp, watched them develop and form Rosettes, and they saw the spores gradually break away.

Dr. Lawrie does not admit, however, that the young parasites which are seen in the blood cells are the same as the spores which break from the Rosettes, and he gives a reason for this assertion, *viz.*, that the "spores are a great deal larger than the speck in the red cell, which is the form in which the proteosoma first appears in the blood." Captain Fearnside makes a very reasonable suggestion that measurements might be given to show this alleged difference in size. Here, again, Dr. Lawrie calls assertion to his aid and says in reply "the difference in size is so apparent that measurement is unnecessary."

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* NOTE—A few parasites may remain.

The spores are not all of exactly the same size: some are larger and some are smaller. The spores change apparently in size. We say apparently, for they are subjected to a certain amount of pressure when placed between the cover glass and the slide, and as a result of pressure they may *appear* to increase in size when they have been left between the glasses for some time. Then, again, the young parasite may not be subjected to the same amount of pressure vertically when it is situated inside a corpuscle, and it may be subjected to more pressure laterally and consequently it may appear smaller. For these reasons we think that even if the parasite when it is inside the corpuscle appears smaller than when it is free in the blood plasma, this does not prove that they are different bodies. But this marked difference which Dr. Lawrie appears to have noticed we have not observed.

A Benign Tertian parasite, when free in the blood and in the young stage, has a peculiar appearance when it is stained with blue. There is a part which stains well with blue and there is the sac attached to this which stains only at its periphery. Now we get exactly the same appearance in the young parasite after it has entered the corpuscle. It would be interesting to hear how Dr. Lawrie would explain this fact.

The next assertion by Dr. Lawrie is :—

> "We deny altogether that either the halteridium or the proteosoma, or any other form of Laveran body, avian or human, possesses the function of reproduction at all. The Rosette is met with so very rarely in the blood, either of birds or of human beings, that it is impossible to regard it as the sporulating element by which reproduction is carried on, and when it is found, the proteosoma forthwith diminish instead of increasing in number."

There are three assertions in this sentence, and, following out the principles laid down by Dr. Lawrie, we shall avoid counter-assertion ; but we would ask attention to one case of Benign Tertian and leave our readers to conclude for themselves what value is to be attached to these three assertions. The chart of the case and the record of the blood examinations are given. Four slides were examined daily and 20 minutes was devoted to each examination.

ABSTRACT OF BENIGN TERTIAN CHART.

Samuel Norbert.

		March.			April.												
Date	..	29	30	31	1	2	3	4	5	9	7	8	9	10	11	12	13
Degrees of fever	..	**5**	**0**	**7**	**0**	**5**	**0**	**7**	**3**	**6**	**0**	**5**	**0**	**0**	**0**	**0**	...
Parasites. Young	...	206	...	49	50	13	5	18	29	10	17	18	12	4	2	...	...
Parasites. Pigmented	...	9	359	302	102	47	64	61	42	16	16	19	19	21	10	6	..
Parasites. Rosettes	...	1	...	24	...	5	1	11	...	2		11	...	...		...	...

Note the fever on 29th, 31st, 2nd, 4th, and the irregularity on the 5th. Compare with the Detailed Record.

DETAILED RECORD OF SAMUEL NORBERT.

Date.	Number of specimen.	Hour when blood drawn.	Temperature.	Young forms unpigmented.	Young forms pigmented.	Middle stage.	Full grown.	Rosettes.	TOTAL.
29-3-01 ...	1	11-30 a. m.	100·6	42	...	...	2	1	45
	2	1 p. m.	102·0	86	...	.	2	...	88
	3	3-40 ,,	102·8	37	...	...	2	...	39
	4	4-5 ,,	102·8	41	...	...	3	...	44
				206	...	..	**9**	**1**	**216**
30-3-01 ...	1	11-15 a.m.	97·6	...	76	2	2	...	80
	2	12 15 p.m.	97·4	...	51	29	...	...	80
	3	2-55 ,,	97·0	...	37	62	...	...	99
	4	4 20 ,,	97·6	...	6	88	6	...	100
				...	**170**	**181**	**8**	...	**359**
31-3-01 ...	1	7-20 a.m.	97·6	...	...	12	131	...	143
	2	7-50 ,,	97·8	1	...	...	124	1	126
	3	9-40 ,,	103·2	...	1	2	19	23	45
	4	11-20 ,,	103·2	48	...	...	13	...	61
				49	**1**	**14**	**287**	**24**	**375**
1-4-01 ..	1	1 p.m.	97·0	31	20	2	...	...	53
	2	1 25 ,,	97·4	17	23	5	...	..	45
	3	3-0 ,,	97·	2	22	3	...	...	27
	4	4-30 ,,	97·6	...	25	2	...	...	27
				50	**90**	**12**	...	...	**152**
2-4-01 ...	1	10 a.m.	97·2	...	...	10	2	..	12
	2	2 p.m.	99·0	...	...	...	13	4	17
	3	2-45 ,,	101·2	...	...	...	15	1	16
	4	4-0 ,,	103·4	13	...	...	7	...	20
				13	...	**10**	**37**	**5**	**65**

Duration of each examination, 20 minutes.

DETAILED RECORD OF SAMUEL NORBERT—(*contd.*)

Date.	Number of specimen.	Hour when blood drawn.	Temperature.	Young forms unpigmented.	Young forms pigmented.	Middle stage.	Full grown.	Rosettes.	TOTAL.
3-4-01 ...	1	3-30 p.m.	97·	3	9	4	...	1	17
	2	4-10 „	98·2	2	10	2	...	...	14
	3	5-0 „	97·2	...	7	11	...	...	18
	4	8-0 „	97·4	...	5	16	..	...	21
				5	**31**	**33**	...	**1**	**70**
4-4-01 ...	1	10 a.m.	98·6	...	...	2	17	3	22
	2	10-45 „	101·4	...	...	...	25	7	32
	3	12-8 p.m.	105·4	7	...	...	12	1	20
	4	2-0 „	103·0	11	...	...	5	...	16
				18	...	**2**	**59**	**11**	**90**
5-4-01 ...	1	10 a.m.	97·2	4	7	..	2	...	13
	2	12 0 noon.	97·6	9	10	...	1	...	20
	3	2 p.m.	98·0	6	9	...	...	..	15
	4	4-0 „	101·2	10	12	...	1	...	23
				29	**38**	...	**4**	...	**71**
6-4-01 ...	1	11 a.m.	97·6	1	..	..	8	...	9
	2	12-0 noon.	98·0	3	...	...	4	2	9
	3	2-15 p.m.	100·6	5	...	1	1	...	7
	4	2-38 „	101·0	1	.	...	2	..	3
				10	...	**1**	**15**	**2**	**28**
7-4-01 ...	1	10 a.m.	97·0	3	4	1	...	...	8
	2	11 „	97·4	4	2	...	...	...	6
	3	12-15 p.m.	97·6	6	3	...	...	...	9
	4	12-40 „	97·8	4	5	1	...	...	10
				17	**14**	**2**	...	...	**33**
8-4-01 ...	1	10 a.m.	98·	...	...	1	8	2	11
	2	12-0 noon.	103·0	1	...	2	3	..	6
	3	12-30 p.m.	104·0	5	...	...	2	...	7
	4	4-0 „	100·6	12	...	...	3	...	15
				18	...	**3**	**16**	**2**	**39**

Duration of each examination, 20 minutes.

DETAILED RECORD OF SAMUEL NORBERT—(*concld.*)

Date.	Number of specimen.	Hour when blood drawn.	Temperature.	Young forms unpigmented.	Young forms pigmented.	Middle stage.	Full grown.	Rosettes.	TOTAL.
9-4-01 ...	1	9 a.m.	97·2	3	3	2	...	...	8
	2	1-24 p.m.	97·6	3	4	2	...	...	9
	3	3-35 ,,	98·0	2	3	...	...	...	5
	4	4-0 ,,	98·0	4	2	3	...	...	9
				12	**12**	**7**	...	...	**31**
10-4-01 ...	1	8-45 a.m.	97·2	...	...	3	2	...	5
	2	10-40 ,,	97·4	1	...	2	2	...	5
	3	3 p.m.	97·8	3	...	2	3	.	8
	4	3-33 ,,	98·0	...	1	2	4	...	7
				4	**1**	**9**	**11**	...	**25**
11-4-01 ...	1	9 a.m.	97·8	1	1	1	1	...	4
	2	10 ,,	97·6	..	...	2	1	...	3
	3	1-18 p.m.	97·2	1	2	...	...	...	3
	4	2-0 ,,	97·4	...	...	1	1	...	2
				2	**3**	**4**	**3**	...	**12**
12-4-01 ...	1	11-22 a.m.	97·6	...	...	2	...	...	2
	2	1-5 p.m.	98·0	...	1	...	..	...	1
	3	2-48 ,,	97·4	...	...	1	...	...	1
	4	3-40 ,,	97·8	...	1	1	..	...	2
				...	**2**	**4**	...	..	**6**
13-4-01 ...	1	9 a.m.	97·0	...	...	1	...	1	2
	2	9-50 ,,	97·6	...		..	1	...	1
	3	12-0 noon.	97·6	...	...	1	...	...	1
	4	2 p.m.	97·0	...	...	...	...	..	
				...	...	**2**	**1**	**1**	**4**
14-4-01 ...	1	9 a.m.	97·6	1	...	1	...	...	2
	2	1 p.m.	97·8	...	..	1	...	...	1
	3	3 0 ,,	98·0	...	...	...	..	..	...
	4	5-0 ,,	97·2	1	...	..	...	...	1
				2	...	**2**	...	...	**4**

Duration of each examination, 20 minutes.

At the foot of the chart is shown the number of young forms, pigmented parasites, Rosettes and flagella forms which were seen each day ; but it is only when we examine the daily record carefully, and note what kind of parasites are seen at a particular stage of the fever, that we are able to see in what way the life history of the parasite is connected with the fever. People who have Tertian fever frequently get fever every day, especially towards the end of the fever, and we often hear them say "but I cannot have Tertian fever, for the fever comes on every day." In this case after four turns of fever on the regular days there was some fever on one of the intervening days, and it is worth noticing what parasites were seen on this day, the 5th of April. If, for convenience, we speak of the day on which fever comes as the *fever* day and the intervening day as the *free* day, we see on the 29th, 31st, 2nd April, 4th (the fever days) that after the paroxysm we find several young unpigmented forms in the corpuscles, and on the *free* days (30th, 1st, and 3rd), we see that the young unpigmented forms get less as the day goes on, and in the evenings there are none ; but on the 5th, which we should expect to be a *free* day, 10 young unpigmented forms were found at 4 P.M. There was a little fever on this day, and some young unpigmented forms were found. It is reasonable to conclude that some Rosettes had broken up on this day and that this was the cause of the fever.

On the 30th, a free day, we see a large number of young pigmented forms and a large number of half-grown parasites. In the morning the majority are young pigmented and in the evening the majority are half grown. Note the figures at each examination:—

Young pigmented parasites	76	51	37	6
Half-grown parasites	2	29	62	88

On the next day, 31st, the young pigmented are scarcely to be seen; there are a few half grown in the morning, and a large number of full grown. At 9-40 the patient began to shiver and 23 Rosettes were counted. Several others were seen by Captain Watson, who happened to be in the Laboratory at the time, but these are not entered in the record, as only those seen at the regular examinations have been noted. At 11-20, 48 young unpigmented forms were seen.

The 1st of April was a *free* day, and we see the young unpigmented forms fairly numerous in the morning but decreasing during the day—several young pigmented forms but no full grown or Rosettes. The 2nd was a *fever* day, and we find in the morning the majority of parasites in the middle stage. At 2 P.M. fever came on and we find chiefly full grown and Rosettes. In the evening the full grown and Rosettes are much less, but we see the young unpigmented forms again taking their place.

On the 3rd, a *free* day, we see the young unpigmented forms getting less and disappearing, the young pigmented forms in the majority and getting less as the day goes on, while the half grown are in small number in the morning but increasing in the evening. There were no full grown, and only one Rosette. It is worth noting that this was the first Rosette which was found on a *free* day, and it shows that a little irregularity was beginning.

On the 4th, which was a fever day, there were no young forms seen in the morning. Fever came on between 10 and 11 o'clock and Rosettes were found, together with a number of full grown. In the evening the full grown have decreased, and the young unpigmented have appeared.

On the 5th, which in the ordinary course we should expect to be a free day, we find something unusual; there were 4 full grown forms and there were 10 young unpigmented forms in the evening, showing that there was a certain amount of irregularity of development, and it was on this day that fever came, on what we might expect to be a free day.

The total number of parasites counted on each day was as follows:—

29th	30th	31st	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
216	359	375	152	65	70	90	71	28	33	39	31	25

There was no fever after the 10th, and it is worth noting how many parasites were found:—

11th	12th	13th	14th
12	6	4	4

Dr. Lawrie's name ranks among the highest as a Surgeon ; but it is hoped that his name as a Surgeon will not put him in the false position of being considered an authority on Malaria.

CHAPTER XIII.

QUOTIDIAN.

MANSON and Celli both describe two kinds of parasites which cause Quotidian fever, one an unpigmented parasite and the other a pigmented parasite. On the other hand, Koch, in his Final Report on the German Malarial Expedition, says that, apart from Quartan and Tertian, which occur among ourselves, there is really only one form of malaria, *viz.*, "Tropical Malaria."

Manson says, in regard to Pigmented Quotidian, that it is smaller than the Tertian, that it occupies from about one-fifth to one-third of the red blood corpuscle, that the young forms are very active and tend to assume the ring forms, and that the Rosette forms little heaps of very minute spores. Celli says the granules of pigment are scarcely visible.

In the first edition of this book, it was stated that two cases seemed to tally with the description of pigmented Quotidian. During the past year or more we have been watching specially for such cases and have not met any. Also we have asked many members of the Malaria Conference if they had seen such cases. We are beginning to doubt the existence of a Quotidian parasite.

A clinically Quotidian fever is common enough, and is most frequently found in Malignant Tertian cases, or in cases with two parasites ; or in the Benign Tertian fever especially in old-standing cases.

CHAPTER XIV.

MOSQUITOES AND MALARIA.

THE literature on the subject of the relation between Malaria and Mosquitoes is already very extensive, and no attempt will be made here to give a full or connected account of the reasons which led Manson to suggest that Malaria was conveyed by mosquitoes or that led Ross to prove that mosquitoes are the carriers. Our readers may refer for information on this subject to Manson's book on Tropical Diseases, to Ross' West African Report, to Celli's book on Malaria, to Christy's book on Mosquitoes and Malaria, to Giles's book on Mosquitoes and to the numerous articles which have appeared in medical and non-medical Journals during the past year for information on this subject. Some experiments have been made in Nagpur in order to show whether the views which have been advanced by some of the writers mentioned above are correct, and a short account of some of these experiments may be of interest.

The mosquito, which has got the credit of carrying the Malaria fever germ, is called anopheles, and after finding the anopheles we began to enquire what time of the year the anopheles is found and whether the time of its presence tallies with the time when the malarial fevers are prevalent. A year has now elapsed since we began to collect anopheles, and a record has been kept of the number caught daily in a given area.

The place selected was the Jail Hospital, and the following table shows the numbers collected in each month between October 1900 and October 1901.

Month and year.		Monthly total of admissions for fever.	Monthly total of anopheles caught.	Lowest record by wet minimum thermometer.
October	1900 ...	105	117	56
November	,, ..	34	139	51
December	,, ..	125	189	52
January	1901 ...	52	43	45
February	,, ...	26	18	45
March	,, ...	23	16	55
April	,, ...	24	15	56·4
May	,, ...	7	12	60
June	,, ...	7	...	62
July	,, ...	12	19	69·5
August	,, ...	21	1,106	70
September	,, ...	119	633	64

Weekly Totals for August and September.

August 1901.			
1st week	5	59	
2nd ,, ..	3	211	
3rd ,, ...	4	382	
4th ,, ...	9	454	
Total ...	21	1,106	
September.			
1st week ...	21	293	
2nd ,, ...	38	117	
3rd ,, ...	22	114	
4th ,, ...	38	109	
Total ...	119	633	

In the months of February to July there was hardly an anopheles to be found. They began to appear in large numbers about the middle of August, and at the end of August the malarial fevers began to prevail.

The next question is—what time are malarial fevers most prevalent—and here it will be interesting to compare the seasonal prevalence of malarial fevers with that of other countries. Celli gives the figures showing the number of admissions for malarial fevers into the hospitals of Rome for thirteen years. If we omit the units and tens, and put down the even hundreds, the figures stand as follows :—

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
46	37	39	39	35	25	88	176	152	127	95	66.

In Nagpur the average number of admissions for ten years in the Jail, with a population of about 1,000, is—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Admissions	81	27	28	12	15	14	81	88	56	56	50	37

In Rome the maximum is generally attained in August. In Nagpur it is later—in September or October. In Rome from November till June there is a general tendency to a diminution of the number of admissions, and the similarity in the Nagpur figures is remarkable.

There has been a great deal of evidence already brought forward to show that in whatever parts of the world malarial fevers are found the anopheles mosquitoes are found there also ; but there probably has not been any experiment made similar to this one, to show whether the anopheles season coincides with or precedes the fever season.* For some months—April, May, June and July—there were very few admissions for fevers, and in those months there was scarcely an anopheles to be found. The anopheles appeared in August, and a fortnight or three weeks later malarial

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*Since writing the above a similar record has appeared in the October number of the *Indian Medical Gazette* by Captain Glen Liston.

cases began to come to Hospital. Then it may be worth while to consider why the anopheles mosquitoes begin to breed in August, and possibly the rainfall may be one of the most important elements to be taken into consideration. The average monthly rainfall omitting decimals at Nagpur for the past ten years is :—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Rainfall	0	0	0	0	0	7	14	12	9	1	0	0

At page 5 of the West African Report, it is shown that the largest number of admissions for malarial fevers occur in the middle of the rainy season. Here the admission rate is greatest after the rains.

We have seen that the seasonal prevalence of anopheles would tend to support the mosquito-malarial theory. Many experiments were made on individuals who volunteered to allow themselves to be bitten, and a short account of these will be given.

First, it was necessary to get a supply of young anopheles. Every little pool of dirty water around the Jail had numbers of the culex mosquitoes, but the anopheles pools were very few. It has been pointed out by many writers that the anopheles prefers a pool with clean water, while the culex will choose a pool with dirty water, and our observations here confirmed this fact. A cook-house pool is the favourite place for the culex, and from one small *tanka* (a small masonry tank) we collected about 4½ millions of culex eggs in a month. The eggs are laid in "boats," each boat being made up of about 250 eggs. Sometimes as many as 1,600 of these boats were deposited on this little *tanka* in a single night, or rather in the early morning, which is the laying time. At one corner of the Jail there was a small clear stream coming from an underground drain (a French drain), and this was the favourite place for the anopheles to deposit their eggs. When the stream ceased to flow, a few pails of clear water were thrown into this drain every morning, and the anopheles continued to lay their eggs there with great regularity as long as any anopheles were to be found. It need hardly be said that the larvæ from this pool were all collected.

The time taken for development was as follows :—After 24 hours the young larvæ came out of the shell; 16 days later the larvæ were transformed into the nymphæ; and in from two to three days the fully-formed mosquito emerged from its covering.

The mosquitoes were kept in large bottles, from which the upper part had been removed, and these bottles were covered by a cap of mosquito netting. At first the netting used had a coarse mesh, but the anopheles was able to pass easily through this, and then fine mesh netting was substituted.

The males were fed on plantains, and the females were allowed to have a meal of blood (only the females suck blood) from the arm of an individual who had a known kind of malarial parasites in his blood.

The time chosen for giving this meal of blood was the evening just after sundown, for then the mosquitoes fed greedily when a man placed his forearm, previously moistened with water, over the top of one of the bottles containing the mosquitoes. The mosquitoes were allowed to bite the same man for four or five nights and then they were allowed to bite one of those who volunteered to be bitten.

EXPERIMENTS WITH BENIGN TERTIAN.

In describing the results it will be well to take each kind of fever separately, and we shall begin with the Benign Tertian. The dates on which the mosquitoes were fed on the individual already infected and the volunteers are here given.

We see that out of seven cases who volunteered to be bitten by the mosquitoes, four were attacked by fever, but in only two of these did we find the Benign Tertian parasite. In case (1) a parasite was found, but it was a young form, and there was no proof that it was a Benign Tertian.

Taking the two cases in which parasites that were undoubtedly those of Benign Tertian were found, we see that the fever came on in one case 22 days after the first bite, and in the other about 15 days after the first bite. It may be said by those who are opposed to the mosquito theory that the fact that the attacks of fever came after the mosquito bites was entirely accidental. This was the objection raised against the cases which were experimented on in Italy. We have carefully examined the blood in every case that has been admitted for fever while these experiments were being carried on, and out of a population of 1,200 (odd) there were only two other cases admitted for Benign Tertian. If the fever in these two cases were not the result of the mosquito bite, would it not be curious that out of seven individuals who were bitten by mosquitoes two should get Benign Tertian fever, while only two other cases occurred among about 1,200 men? and would it not be still more curious that the time when the fever came on was about a

QUARTAN.

Serial No.	† *B.* Name.	* *A.* Name.	Date when fed on * *A.*	Number of bites on * *A.*	Date when fed on † *B.*	Number of bites on † *B.*	Date when † *B.* was attacked by fever.	Kind of parasites found.	Nature of fever.
1	6610 Seetia	483 Sitaram	16th to 19th Dec. 18th to 22nd do.	15 16	21st to 29th Dec. 23rd to 31st do.	25 35	*Nil.*	*Nil.*	*Nil.*
2	7413 Ghidoo	Do.	2nd to 5th Jan.	31 17	6th to 8th Jan. 9th to 21st do.	23 58	5-2-01	Not distinct.	102 Temp.
			5th to 8th do.	17	9th to 21st do.	30			
3	6474 Nago	Jan Mahomed	21st to 25th Dec. 29th to 31st do.	16 20	25th to 31st Dec. 5th to 9th Jan.	38 25	*Nil.*	*Nil.*	*Nil.*
4	7133 Pustan	2267 Sambhoo	9th to 13th Jan. 12th to 15th do.	15 38	13th to 17th Jan. 16th to 20th do.	17 15	"	"	"
5	7422 Balia	350 Jangli	4th to 6th Feb. 5th to 7th do.	19 16	8th to 17th Feb. 11th to 16th do.	24 10	"	"	"
6	7004 Sadaram	Do.	6th to 8th Feb. 7th to 9th do.	21 7	9th to 16th Feb. 10th to 12th do.	23 7	"	"	"
7	7323 Jairam	382 Panchoo	4th to 6th Feb. 7th to 9th do.	11 16	8th to 11th Feb. 10th to 13th do.	12 5	"	"	"
8	7277 Barkia	Do.	6th to 8th do.	31	9th to 16th do.	51	"	"	"
9	3156 Abdul Aziz	492 Jeolagya	12th to 16th Mar.	24	20th to 24th Mar.	21	"	"	"

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* *A* = the man on whom mosquitoes were fed primarily,
† *B* = the man who was bitten by the infected mosquitoes.

infection does not appear to be the same as the season for the Malignant Tertian infection, and perhaps the Benign Tertian infection.

EXPERIMENTS WITH MALIGNANT TERTIAN.

Seven men were bitten by anopheles that had been fed on cases that were infected with Malignant parasites. Of these, one got fever (102·8) three days after being bitten and Malignant Tertian parasites were found. In another case no fever was noticed, but 23 days afterwards a Crescent was found. In 5 cases no fever followed and no parasites were found in the blood.

What conclusion can be drawn from these experiments? The evidence in favour of Benign Tertian being conveyed by mosquitoes has been discussed, but as regards Quartan there is no evidence at all that it is conveyed by anopheles. Take, for instance, the case of Seetia, the first on the list. He was bitten 83 times by mosquitoes that had already bitten a man with Quartan parasites, 62 times, and yet no fever followed. If anopheles carry Quartan then it would be difficult to explain why he was not attacked unless we assume that (1) he was immune, or (2) that the anopheles did not bite him at the time when the parasite was in a suitable condition, or (3) that the season was not one in which the Quartan parasite could develop properly, or (4) that the species of anopheles used in the experiment was not the correct one.

Similarly, if we take the first case in the Malignant Tertian list, we see that the anopheles bit a man who was infected with Malignant Tertian para-

MALIGNANT TERTIAN.

Serial No.	†B Name.	*A Name.	Date when fed on *A.	Number of bites on *A.	Date when fed on †B.	Number of bites on †B.	Date when B was attacked by fever.	Kind of parasites found.	Nature of fever.
1	520 Bhagthram	274 Sagun ..	15-2-01	49	19-2-01	31	*Nil*	*Nil*	*Nil*
2	529 Indru ...	7656 Gosai ...	15-2-01	43	19-2-01	48	*Nil*	*Nil*	*Nil*
3	663 Hania ...	42 Lachmaya	16-2-01	46	19-2-01	22	*Nil*	*Nil*	*Nil*
4	7338 Raghoba ...	88 Narhari...	17-2-01	20	21-2-01	17	*Nil*	*Nil*	*Nil*
5	7320 Mohan .	Do. ...	17-2-01	18	21-2-01	11	24-3-01	Ring forms (M. T.)	102·6 Temp.
6	7394 Goma ...	475 Seetia ...	18-2-01	32	21-2-01	25	16-3-01	Crescent form	*Nil*
7	Bisan ..	Do. ...	23-2-01	24	27-2-01	13	*Nil*	*Nil*	*Nil*

sites, 49 times, and 4 days afterwards these same mosquitoes bit a healthy man 31 times and yet no fever followed and no parasites were found in the blood.

On the other hand, we have seen that the season when the anopheles are most abundant is just a few weeks before the season when the malarial fevers begin to prevail.

Manson has proved conclusively that the Benign Tertian can be conveyed by the anopheles mosquito, but in regard to the other fevers there is not apparently any evidence that they are carried by mosquitoes, and the only conclusion that may be fairly drawn from the experiments that have been made here is that a man may be bitten very often by mosquitoes which have been already fed on an individual who has undoubtedly Quartan or Malignant Tertian parasites in this blood and yet not suffer from an attack of fever nor have any parasites in his blood.

The whole subject is one which requires to be much more fully investigated.

Subsequent note.—

In Part II it will be shown that the effect of temperature had not be taken into consideration and that the low temperature was probably the cause of failure to infect.

CHAPTER XV.

SEASONAL PREVALENCE OF MALARIAL FEVERS.

We have already seent hat the time of the year when the malarial fevers are most prevalent is in the months of September and October, and that the number then gradually diminishes. In Italy the fevers have been divided into two groups, one called the Æstivo-autumnal, and the other the Spring fevers. In the former, the Italians put the Malignant Tertian and Quotidian, and in the latter, the Quartan and Benign Tertian. We propose here to enquire what kinds of malarial fever prevail at particular seasons, and in the table given below the total number of admissions for each kind of fever during the past ten months have been entered.

Statement showing number of admissions by months uith different varieties of parasites.

Month.	Quartan.	B. Tertian.	M. Tertian.	Double infection.	Total.
				M. T. and B. T.	
November 1900 ...	...	...	...	..	...
December ...	3	5	24	...	32
January 1901 ...	4	3	16	...	23
February .	1	...	12	..	13
March ...	1	...	5	...	6
April ...	1	...	...	...	1
May ...	...	...	...	...	0
June ...	...	3	...	...	3
July ...	...	3	...	...	3
August ...	1	3	10	..	14
September ...	1	39	51	3	94
October ...	...	...	...	...	...
TOTAL ...	12	56	118	3	189

QUARTAN.

There were altogether 12 Quartan cases excluding those with mixed infections. From May to July no Quartan case was admitted. Some of the men who had been admitted during the cold weather had Quartan parasites in their blood throughout the greater part of the year, although they were not getting Quartan fever. One of those who was admitted in September and had Quartan parasites in his blood was an old case (Jangli) who had been in hospital in the winter time; he got an attack of Influenza in September, so his admission might have been shown under Influenza rather than under Quartan.

BENIGN TERTIAN.

In the first eleven days of September there were 18 admissions for Benign Tertian, whereas there were only 11 admissions for Malignant Tertian in the same time. Between the 11th and the end of September the number of admissions for Benign Tertian was only 21, while the number admitted for Malignant Tertian was 40; but during this latter period a weekly dose of quinine, 20 grains, was given to 400 men, and it will be shown later on that this weekly dose of quinine had probably a greater effect in checking the Benign Tertians than the Malignant Tertians. As there were, however, in the month of September nearly as many Benign Tertians as there were of Malignant Tertians, the numbers being 39 Benign to 51 Malignant, it would seem that the term Æstivo-autumnal, which the Italians have applied to the Malignant Tertian, is misleading. In January, February and March there were many more Malignant Tertians than Benign carried out a similar series of experiments to show whether arsenic has any effect in killing the other parasites, still we are not aware of any experiment that has been made to prove that arsenic is of the slightest use. Arsenic acts as a tonic, and in that way it may ultimately be useful as a parasiticide, but there does not appear to be any proof that it is effectual. The two remedies that are relied on now are quinine and methylene blue.

No one doubts the efficacy of quinine, and it may be asked, why should we bother about another remedy as long as we know that quinine is effectual. There are three reasons :—Methylene blue is cheaper, it can be produced artificially in large quantities, and there are some conditions in which a patient cannot bear quinine. One of these is pregnancy. A dose of three grains of quinine and followed by three in the evening has been found to cause very troublesome contractions of the uterus, and it was only by the administration of the tincture of opium that such contractions were stopped. In such cases it is with the greatest hesitation that one can venture to give even small doses of quinine, and we should be glad to find another drug that would act as well in causing the death of the parasites, while it would not set up contractions of the uterus.

QUININE.

We have already seen that there is no disease in which the effect of a drug can be so thoroughly tested as in Quartan fever. Its great regularity and its liability to recurrence make it an exceptionally simple disease for experimental purposes. Twenty grains of quinine given on the first day, the second day, or on the third day of the cycle of development will stop the paroxysms for a time. But although it is easily stopped there is probably no parasite so persistent inasmuch as a few parasites may be found for months after the original attack of fever. We have been able to find the Quartan parasites, but in very small numbers in cases that were under observation for Quartan over six months ago. These cases had received only one dose of quinine and they were kept under observation from time to time for several months. In order to completely extirpate the Quartan parasites, it would be necessary to give repeated doses of quinine at intervals of a week or so.

Most cases of Benign Tertian can be stopped in a day by quinine, but the doses required are probably a little larger than for Quartan. However, a good deal depends on the number of parasites found. The Malignant Tertian is the most difficult to deal with. If it is a mild case with only a few parasites it may be stopped quickly with quinine; but a severe case with a large number of parasites will not be readily checked. The important point in the treatment is to give doses sufficiently large to prevent the formation of Crescents and to prevent the Secondary or Flagellar fever. It will often be necessary to give as many as forty grains in the day to an adult for this purpose.

We have given forty grains in one day to a Malignant Tertian case, and yet the fever was not stopped, and the Flagellar fever came on. The quinine was not, however, given at the commencement of the fever. In others a dose of twenty grains a day for several days has not been sufficient to check the formation of Crescents. In one case the formation of Crescents was checked by giving forty grains on the first day, thirty on the second, twenty on the third, and then ten grains daily for some days. But the dose should be regulated by the severity of the case and the number of parasites found. Captain Johnston, I.M.S., has found that the formation of Crescents can be prevented by the hypodermic injection of quinine, but if the Crescent formation can be checked by the administration of quinine by mouth, few people will be willing to submit to the hypodermic method even though a smaller dose is required.

The enormous benefit to be derived from the use of quinine can scarcely be exaggerated. There is probably no medicine employed to check any disease that can compare with it, and although one has always had a certain amount of belief in its value, it is only after a long series of experiments that we begin to realize its wonderful power. There is no medicine so useful when properly used, but there is probably no medicine which is so much abused. How often do we see it given at random in cases which are not malarial at all, and in which it may probably do much harm, for although not a poison in ordinary doses, still its effects are to a certain extent poisonous, and it is only when we are certain that there are malarial parasites present that its use in very large doses is at all justifiable.

Many experiments have been made with methylene blue in Quartans and the two Tertians. When it is given, the patient should always be warned that it will turn the urine blue. It is excreted by the kidneys, and it is liable to cause some irritation and pain in the kidneys. It has been given in doses of 3 grains three times a day. Quartans and Benign Tertians are stopped by it, but not so certainly nor so quickly as by quinine. Its effect in Malignant Tertians is being tried at present.*

PROPHYLAXIS BY MOSQUITO NETS.

In the March number of the *Practitioner*, Manson gives an account of the experiments which have been made in Italy by inducing men to live in mosquito-proof houses, and the results of the experiments are very strongly in favour of the Mosquito Malarial theory. In most of the cases there was a check experiment, that is, there were some people at the same places who did not live in mosquito-proof houses. If we put down a few of the figures showing on the one side the number protected by mosquito curtain and the number of cases of fever that occurred among them, and, on the other side, the number unprotected and the number of cases of fever that occurred among them, the difference in the incidence of fever is very striking thus :—

Protected.			*Unprotected.*	
Number.		Got fever.	Number.	Got fever.
52	...	2		Almost every one.
52	...	0	51	Only 7 escaped.
36	...	2	52	Only 7 escaped.
30	...	2	37	Only 2 escaped.
104	...	3	25	All got fever.

These are only a few of the results of the experiments which Manson gives, but they serve to show the enormous value of the mosquito curtain. The mosquito curtain may act by keeping out mosquitoes, or it possibly may act by keeping out some germs that are borne by the air. The fact that Benign Tertian has been proved to be conveyed by mosquitoes would favour the former view; whereas the fact that in our experiments so many men have been bitten by infected mosquitoes and yet such a small proportion of them got fever might be held to favour the latter view.

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* See result of experiments in Part II.

PROPHYLAXIS BY QUININE.

We have frequently given small doses of quinine to one lot of men during the fever season while another lot received no quinine, and we have compared the number of admissions from each lot. A similar experiment is being made in the present year but with this difference, that the kind of parasite found in those who are admitted from each group is recorded, and instead of giving small doses three or four times a week, one dose of twenty grains is given once a week. The experiment was begun on the 11th September. The twenty-grain dose was given to 400 men once a week, and the weekly totals of admissions from these 400 are given in the table below. The total number of admissions from the remainder, about 600 to 700, are also given:—

	Received quinine.				*Not receiving quinine.*			
	Quart	B. T.	M. T.	No parasite	Quart	B. T.	M. T.	No parasite.
1st week ...	0	3	7	1	0	7	8	11
2nd „ ...	0	0	2	1	0	2	16	8
3rd „ ...	1	0	1	4	1	9	8	30
4th „ ...	0	0	4	6	1	6	11	14
5th „ ...	0	1	3	1	0	2	7	8
6th „ ...	0	0	0	0	0	2	2	10
Total to 21st Octr.	1	4	17	13	2	28	52	81

A slight epidemic of Influenza occurred while this experiment was being carried on, and that probably accounts for so large a number of fever cases in which parasites were not found. But it is curious that the proportion among those who were not taking quinine was so much greater than among those who were taking quinine.

If we consider the effect of the prophylactic dose of quinine on each class of fever, we find among the quinine group one Quartan, but this case was one in which Quartan parasites had been present for many months, and he had a slight attack of Influenza which was probably the cause of the fever. There were two Quartans among those who were not receiving quinine.

Benign Tertian.—Of the four cases that occurred among the quinine group, two were admitted on the day after the first dose of quinine was given and one on the fourth day. After that, the Benign Tertian almost disappeared from the quinine group. From the non-quinine group there were 28 Benign Tertian cases admitted. A weekly dose of twenty grains would probably prevent nearly all admissions for Benign Tertian.

Malignant Tertian.—The numbers gradually decreased among the quinine group. There were seventeen altogether, and in the non-quinine group there were 52, so quinine has not such a marked effect in preventing Malignant Tertian.

A further experiment is being made by keeping a number of men inside mosquito curtains from sundown till day-break. Their blood was examined carefully on three days so as to ensure that none of them had already had parasites in their blood. It was necessary to reject 10 altogether out of about 46 on this account. It is now past the middle of October (21st), and the Malarial season is almost at an end. Up to the present time none of those who have been confined in the mosquito curtains have had fever.

CONCLUSION.

Whatever doubts we may have in regard to the part that mosquitoes play in carrying Malarial fever germs, there are two facts which have been proved conclusively: first, that the growth of Malarial parasites can be checked by quinine, and second, that Malarial fevers can be almost entirely prevented by the use of mosquito curtain. We hope to continue our experiments with a view to determining what part the mosquitoes play; but for the present it is satisfactory to think that our knowledge of Malaria has progressed in recent years in a way that the most sanguine enthusiast could scarcely have dreamt of a few years ago. It would be rash to expect that the Native population will universally be benefited in the immediate future by the new light which has been thrown on this question, but it is, we think, reasonable to hope that the numerous Europeans who are employed in this country will benefit enormously by the knowledge derived from recent researches. There is a large Jail population, and if Malarial fevers are checked among them, the result will be a great saving to Government, and a valuable lesson to the Native population generally.

Jenner's discovery of Vaccination and Lord Lister's discovery of the use of Antiseptics have conferred incalculable advantages on mankind, and there is every reason now to hope that the recent discoveries regarding Malaria will confer an equal, if not a greater, boon on residents in Tropical and sub-Tropical climates. Whether the credit will be given to Laveran,-the discoverer of the parasite, or to Celli, Grassi, and the numerous other Italians who differentiated and described the various kinds of parasites, all must agree that there are two English names which in any treatise on the subject of Malaria deserve to be written in large letters—the one **MANSON** the other **ROSS.**

Very little need be added in regard to Quartan fever. A few cases which were kept under observation during the time of the Malaria Conference showed the remarkable regularity of development and also the remarkable persistence. The 20-grain dose of quinine has never failed to stop the fever. We have not been able to convey the Quartan experimentally. Quartans are rare in the autumn time, but are found in the first three months of the year.

As regards the Benign Tertian fever also there is little to be added. We have not been able to determine at what time, in the course of the disease, the sexual forms are to be found. By injecting the blood of an individual who was infected with Benign Tertian parasites into another individual, we were able to infect the second individual, but although the parasites could be found in the blood, only a very slight amount of fever followed, and that only in one case. Blood-containing parasites was injected into two monkeys : and although the blood of the latter was examined daily, no parasites could be found.

Many more observations have been made in regard to the Malignant Tertian, and especially in regard to the secondary or what we called the Flagellar fever.

The Quotidian parasite we are beginning to believe is a myth. Although we at first found two or three cases which seemed to tally with the description that had been given of Quotidian, we now believe that these cases were Malignant Tertian, and not one case of Quotidian has been found in the past year, although special attention was directed to the question of the existence of a separate parasite.

A word may be said in regard to the advantage of diagnosis with the aid of the microscope. When we know what we are dealing with, and when we know that a person has malarial parasites in his blood we give large doses of quinine with confidence. During the past year we have rarely met any case of malaria fever, even of Malignant Tertian, that could not be stopped within 24 hours. It should be stated that none of the cases were of the very severe type that is sometimes seen. For instance, several years ago in the Lushai Expedition we saw in one small camp by the Mat river a number of sepoys who were attacked by what seemed to be a severe form of malaria fever, in which vomiting and diarrhœa were prominent symptoms, almost like, but certainly not cholera. It would be interesting to know what parasites are present in such cases,—whether the severity of the attack is due to a special form of parasite, or to special virulence of the parasite, or to the presence of large numbers of the ordinary parasites.

The form of fever—Black water fever—which is so prevalent on the West Coast of Africa, and which we have been on the look out for, for many years, we have not seen, although we have seen many cases of the ordinary malarial fever in Baluchistan, the Punjab, the Central Provinces, Lushai, Assam and other parts of India. Cases are, however, met with in the Duars.

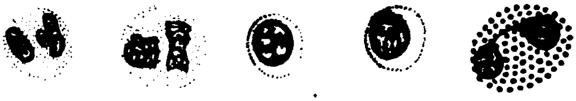
PLATE IX.

VACUOLES.

CRENATED CORPUSCLES.

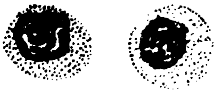
LEUCOCYTES.

Stained with Romanowsky

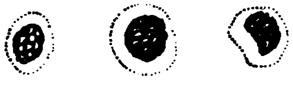


Stained with Eosin and Methylene blue

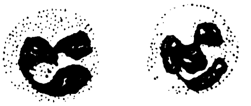
Mononuclear (Large)



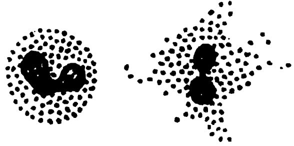
Mononuclear (Small)



Polymophonuclear.



Eosinophile cells.



CHAPTER I.

HINTS TO BEGINNERS WHEN SEARCHING FOR MALARIA PARASITES.

It will seem unnecessary perhaps to tell a beginner to see that he has the right side of his slide up when he puts it on the microscope, but the old Laboratory man will admit that he has often wondered why he could not find the focus, and how at last he discovered that the film side of his slide was down. So always look twice at a slide before you put it under the microscope. Take a dry film uncovered by a cover-glass, and if it happens to be a thin film, notice how difficult it is to say whether you have the right side up. Next hold it out in front of you, so that the light falls on it slanting-wise, and you will see a dull surface on the film side, but a shining surface on the other side. If you don't realise this difficulty, you will be certain to make mistakes and waste a great deal of time trying to find the focus.

The cedar-wood oil which is sold in India is usually very thin. Those who have been accustomed to work with the thick cedar-wood oil, which is sold in England, know that after the oil immersion lens touches the oil they screw down the fine adjustment. But when using thin oil it is usually necessary to screw the fine adjustment up after touching the oil. Those who are in the habit of working with the microscope in a sloping position will find that the thin oil runs off the slide. Dr. Powell of Bombay has been using castor oil instead of the cedar-wood oil, and he thinks it is a good substitute, but he says that care should be taken to test the oil in order to see that it is not acid as the acid may injure the objective.

The absolute beginner will almost invariably ask when he looks at the microscope, what is the big round thing? and without looking to see, we generally say it is a bubble.

In the dusty climate of India there will always be a small particle of dust in the eyepiece, however careful we are, and when this happens to lie over a red blood corpuscle it often looks very like a Ring form parasite. Turn the eyepiece round or move the slide and see what happens to the Ring form. The particle of dust moves with the eyepiece.

There are fine particles or cells in some specimens of blood, and when one of these happens to lie over a red blood cell, it also makes a most perfect Ring form for a beginner. Ko Tha Aung gave us a hint about this, which we have found very valuable. Touch the cover-glass with a needle, and the blood dust moves off the corpuscle. It should be stated that it is in wet films that the blood dust is likely to simulate the Ring form.

But it is the vacuole which is the real puzzle to the beginner. If you watch a Ring form for some time, you will often find that it sinks down or rises up and what had the appearance of a ring, with a part in the centre which is of the same colour as the remainder of the red blood cell, becomes uniformly colourless. A vacuole may present very much the same appearance, and we often had great difficulty in distinguishing between these two, until Ko Tha Aung discovered an extremely simple, but most useful method of distinguishing the vacuole from the spread out Ring form. This is to alter the focus slightly : the vacuole spreads out or gets smaller, but the limits of the parasite remain the same. This is a wonderfully useful hint when examining Malignant Tertian cases.

Then the red blood cells will occasionally be cracked or torn, and if the tear does not extend to the edge, we may have a very good imitation of a young parasite with its arms extended in different directions. But when the arms of the parasites are thus extended they are always amœboid.

In our College days we were told that there were two kinds of corpuscles in the blood, but we occasionally see a very large red blood cell, called a megalocyte, and small red blood cells called microcytes. The white blood corpuscles require much more elaborate study than can be given to them here, but you will have to make yourselves familiar with the polymorphonuclear cell, the large mononuclear cells, the small mononuclear cells, and the eosinophile cell. To study these, a well stained specimen will be a great advantage. You will also have to consider which of these are the phagocytes or scavenger cells.

A very good way to find the focus quickly with the oil immersion is as follows :—

(1) Put the drop of cedar-wood oil over the thickest part of the film. In a good moist film there

may be so few corpuscles in the middle of the film that they may not be noticed.

(2) Examine with the low power (one-third), arrange the lighting, and make certain that there is a thick layer of corpuscles in the middle of the field.

(3) Turn on the oil immersion, and lower till it meets the oil.

(4) Continue lowering very slowly and cautiously by means of the fine adjustment until you find the focus. If the oil is very thin and you are examining a dry uncovered film, it may be necessary to screw up first.

CHAPTER II.

FILMS OF BLOOD FOR EXAMINATION.

Blood may be examined either in wet or in dry films. Each method has its advantages and disadvantages. The method of making the moist films will be described first. If we draw a drop of blood and put it on a slide, the red blood cells tend to run together into "rouleaux," and while they are arranged in this way, it is difficult or impossible to see the parasites that may be inside any of them. Special precautions have to be taken in order that the blood corpuscles may spread out and lie flat on the surface of the glass. The slides and cover-glass must be thoroughly clean, and there must be no waste of time in putting the cover-glass down on the slide. If the slides or cover-glasses have been used before, and if vaseline has been applied to them, they should be washed well in turpentine, then with warm water and soap, and finally in alcohol so as to remove all traces of grease. The part of the body from which the blood is to be drawn should also be well washed with soap and water and afterwards with alcohol. The first drop of blood that comes out after the finger has been pricked should be cleared away as it seems to clot more quickly than blood that comes subsequently. It is better to catch the cover-glass with a pair of forceps and not touch either slide or cover-glass with the fingers.

Various kinds of prickers may be used. An ordinary needle does very well, or for children a needle passed through a cork so that only the point projects, is very good. We have often used a pricker made from a piece of old clock spring. It can be easily sharpened and be readily sterilized. It is of this shape :—

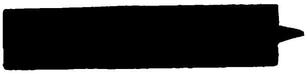


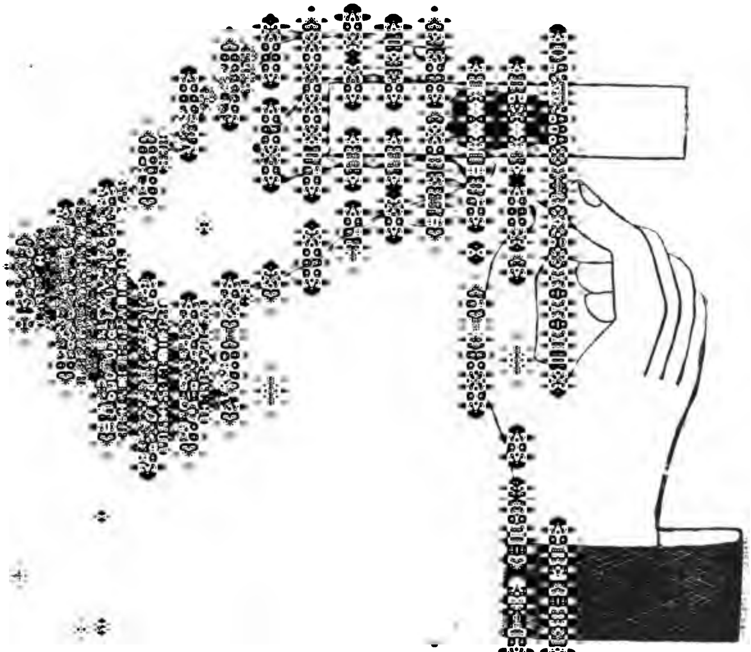
FIG. 1.—DIAGRAM OF PUNCTURING NEEDLE.

Last year the Burmans made a small box for holding the articles that are required for taking specimens of blood. It contained the following articles :—

Slides.
A small box of cover-glasses.
Pair of forceps.
Small bottle of alcohol.
Pricker.
Piece of tape or fine rubber tube.
Small tube with vaseline and brush.

If a piece of tape or rubber tube be tied round the finger, the prick is less painful, and the blood comes more easily. The first drop of blood is taken away with the side of the pricker, and when the cover-glass has been picked up in the forceps, the ball of the finger is squeezed. As a drop of blood comes out, it is touched with the cover-glass as quickly as possible. The drop of blood may form a clot on the glass and, if so, the specimen is useless, and another drop should be taken. If, however, everything is thoroughly clean, and no time has been lost in putting the cover-glass [illegible] out and the [illegible] it up to the [illegible]

[illegible] of the cover- [illegible] Now, if it is [illegible] may be diffi- [illegible]ve had small [illegible] ends of the [illegible] These have [illegible]



[illegible] SPECIMEN.

For studying the parasites the wet film method has many advantages as we are able to watch the movements and changes of the parasites. But if we merely wish to make a diagnosis in any particular case, the dry film method is sometimes more convenient. No special care is required in regard to cleaning the finger or the glasses. The finger is pricked, the slide is applied direct to the drop of blood, and the drop is spread out with a needle. Allow the needle to rest on the drop of blood for three or four seconds, and you will see the blood running along the needle. Then draw the needle along the slide. In half a minute the film is dry, and it can easily be carried away for fixing and staining, as will be described later on. The diagram on previous page will illustrate this method. It was first described by Drs. Christophers and Stephens.

Advantages of taking a moist specimen :—

(1) Less time is required.
(2) The movements of the parasites can be watched.

Advantages of the dry specimen :—

(1) No special precautions are required ; anyone can take a dry specimen.
(2) It is more easily carried.
(3) It may be kept for some hours or for days.

Daily Routine:

As a daily routine in practice the following method is recommended :—

(1) Take dry slides on the morning round, write name on each slide. This can be done with a needle on the film.

(2) Put these in a bottle of alcohol on returning home. A wide-mouthed bottle four inches high, *i.e.*, sufficient to cover the slides. It should have a well fitting stopper to prevent evaporation.

(3) After ten minutes or longer take the slide out; dry in air, put in a small dish (a photographer's dish answers well).

(4) You have ready prepared your stock solution and working solutions of Romanowsky stain.

(5) It is well also to keep two small graduated tubes and a small stand for the working solutions.

(6) Having put required quantities of the two stains in these small tubes, pour the contents on the slide quickly, allowing the two solutions to fall on the film at the same moment, and not one after another.

(7) Hand the dish to an assistant who will manœuvre it so that the stain comes equally in contact with all parts of the slides.

(8) After from ten minutes to half an hour remove the slides ; wash thoroughly in clean water ; dry with filter paper and examine with oil immersion.

CAUTIONS.

(1) If the needle is not allowed to rest on the drop of blood for a second or two before it is drawn along the slide, you won't get a good specimen.

(2) If the needle is pressed too tight against the slide, the specimen will be too thin. If you press too lightly, it may be too thick.

(3) Keep your alcohol free from water; don't use rectified spirit instead of alcohol.

(4) After removing the slides from the alcohol, dry them in the air. When dried, wipe with a fine piece of muslin.

(5) Occasionally filter your working solution of blue.

(6) After staining, wash in water and, after drying, wipe again.

(7) Remember that white corpuscles, blood plates and quartan parasites and Rosettes often lie at the edges or ends of the dry film.

CHAPTER III.

THE ROMANOWSKY STAIN.

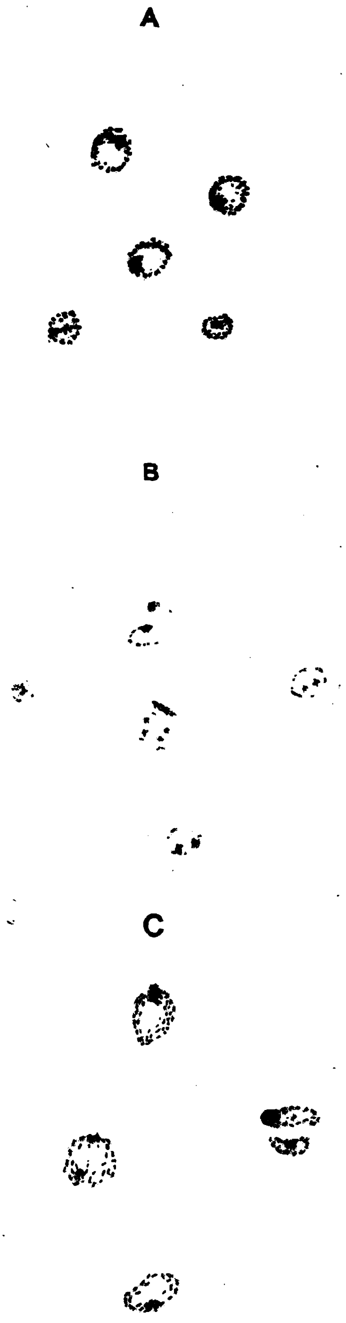
THE coloured pictures, given in the early part of this book, show the parasites as stained by eosine and methylene blue. Various strengths of eosine and blue have been recommended, but we have generally found that the weaker the solutions are the better. With eosine the red blood corpuscles are stained—a red colour, and the granules of the eosinophile cells are stained a still more brilliant red or vermilion colour. The nuclei of the white blood cells stain a blue colour.

The Romanowsky stain is the one which is now most commonly used. It is a combination of eosine and methylene blue, but by making the combination in a certain way and of a particular strength a third stain is developed which gives, what is called the chromatin of the parasites, a brilliant red colour. When beginning to use this stain it is necessary to understand that the parasites and blood cells present quite a different appearance from what they show after staining by the ordinary eosine and blue method. The red stain, it is said, comes from the methylene blue, and it is important to know that only a particular kind of methylene blue is suitable. (This is obtainable at Ball & Hobson's, Umballa.) The process of staining is as follows :—

The films are first fixed by immersing the slides for ten minutes in alcohol, and a covered wide-

QUARTAN AND BENIGN TERTIAN PARASITES STAINED WITH ROMANOWSKY.

PLATE X.



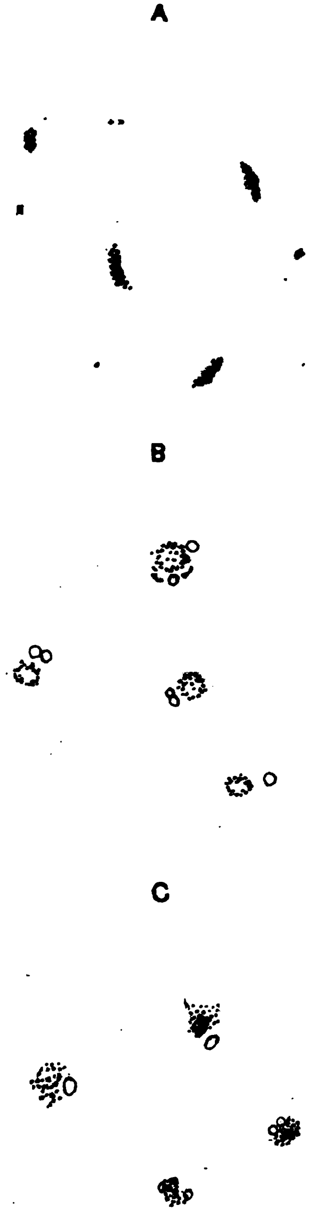
A. Quartan parasite stained with Romanowsky. The Ring form is not represented.

B. Young Benign Tertian parasites. Two or three are sometimes found in one corpuscle. There is sometimes one dot of chromatin and sometimes there are two. The chromatin is usually on the circumference of the blue ring, but occasionally it appears in the middle of it. When a young parasite is entering the red blood cell the chromatin end is probably the last to enter.

C. Benign Tertian parasites, half grown. In the protoplasm of the invaded red blood cell, there are a number of red dots called Schuffner's dots.

MALIGNANT TERTIAN PARASITES STAINED WITH ROMANOWSKY

PLATE XI.



A. Crescents and Ring forms.

B. Female gamates (crescents), moist-chambered for five minutes.

C. Male gamates (crescents), moist-chambered.

mouthed bottle is useful for this purpose. The stains are made up and kept in stock solutions, and the working solutions are kept in larger bottles.

Stock Solutions.

The stock solutions are made as follows :—

I.	Eosine B. A. 0.1 per cent watery solution.	
II.	Methylene blue (Medicinal pure)	1 part
	Carbonate of Soda (not bicarb.)	0·5 „
	Water	100 „

Working Solutions.

One c. c. of each solution, diluted with 24 c. c. of distilled water, in separate bottles, *i.e.*, 1 in 25.

Method.

Put three parts of the eosine in one glass, and two parts of the blue in another. Place the slides (with films already fixed) in a photographer's dish. Pour the two solutions on at the same time. Move the dish, as in photography, for ten minutes to half an hour.

Many failures may be expected, but it is worth while persevering, for a properly stained specimen is very beautiful. The red blood corpuscles should stain salmon pink, but most often they will be a light greenish colour. The young parasites come out particularly well, and the dots of red (chromatin) on the blue ring are very characteristic. The Quartan Ring form can scarcely be distinguished from the Malignant Tertian Ring. The Benign Tertian is generally larger and more irregular. Throughout the red blood cell into which a Benign Tertian parasite has entered we soon find what have been called Schuffner's dots. These stain red, and they are diagnostic of Benign

Tertian. Dr. Powell has said that he found them in Malignant Tertian, but we have never seen them in any but Benign Tertian cases. It is not at present known what they are, but the change which takes place in a corpuscle after a Benign Tertian parasite has entered it, seems very curious.

Some illustrations are given to show the appearance of the Malignant Tertian Gametes (crescents) after being moist-chambered. The moist-chambering is done as follows :—

Take a pane of glass and a piece of folded blotting paper ; cut rectangular holes in the blotting paper (¾ inch by 1½ inch). Moisten the blotting paper and put it on the glass ; take films of blood—dry method,—and invert these quickly over the holes in the wet blotting paper. Allow to remain for five or ten minutes. Take the blood from a crescent case during the flagellar period. The flagella are given out, and they may be stained with Romanowsky or with Carbol-fuchsine.

CHAPTER IV.

BLOOD PLATES AND BLOOD DUST.

It is remarkable that until very recently little attention had been directed to the small particles which are found in the blood, and to which the names Blood Plates and Blood Dust have been given. A Captain in the Indian Medical Service, writing to us recently, has given a very good description of the difficulties which he experienced in regard to these particles, and as the same difficulties may frequently present themselves to others, the following extract is given from his letter :—

> "I have been a good deal puzzled by constantly finding small round and irregularly shaped bodies—sometimes looking almost like single cocci ; sometimes two together like diplococci, sometimes in threes. The bodies are larger than the ordinary pigment granules of the parasite : sometimes they are smaller : some are motile : most of them have a jiggy movement like ordinary Brownian movement, and in addition to this a migratory movement. The bodies are not pigmented and often assume a delicate greenish tint. I am constantly noticing these bodies both in blood in which I find parasites and in non-parasitic blood, or rather in blood in which I do not find parasites."

We have recently received two of the latest books on the blood, one by Coles and the other by DaCosta. Both these authors describe the blood plates, and DaCosta also describes what have been called Hæmoconia. Taking first the *Blood Plates,* we find the following descriptions in the two books mentioned above :—

COLES.	DaCOSTA.
Pale yellow	Either almost colourless or pale yellowish tint.
In fresh blood examined quickly small round or oval bodies about 2·3½ mm. in diameter.	1 to 3 or 4 mm. tend to adhere in racemose masses at or near the radiating points of the fibrin network.
In a few seconds they run together into grape-like clusters Ultimately very thin filaments are seen starting from their angular projections : remarkable for their adhesiveness.	See above.
Increased in number in anæmias unattended with fever ; diminished in malarial fever.	Increased in pernicious anæmia, severe secondary anæmias ; diminished in malarial fever.
They are seen in fresh blood specimens made as quickly as possible.	Exposure to the air causes them to disappear.

Coles and DaCosta are here evidently describing a very definite structure, and their descriptions tally in regard to the main points. We may briefly indicate how far our observations agree with those of the above writers—

(1) Colour : clear and not at all yellow.

(2) Size : the diameter is about $\frac{1}{4}$ that of a red blood corpuscle.

(3) Tendency to run together : Coles seems to think that they run together after the blood is drawn ; but in a dry film spread out at soon as possible with a needle, we have found them more in groups than

singly. As a rule, there are 8 or 10 small cells in each bunch, but we have seen as many as a hundred.

(4) Adhesiveness: Coles says they are most numerous where the blood first comes in contact with the slide, but in the needle film we have often found them most numerous at the end of the film, or at the margins--that is wherever the polynuclears are found. We have, however, sometimes found them most numerous at the beginning of the film. In blood which was allowed to stand for two minutes before preparing the film we have noticed more of the single cells than we have seen in other specimens.

(5) Relation to fibrin. In the needle film no fibrin is seen, but in the moist film specules of fibrin are seen radiating out from the small bunch of cells.

(6) Relation to anæmia. We have found them most numerous in cases of anæmia. In a specimen of blood taken from an extreme case of pernicious anæmia, on the day before death, we did not notice any special abundance.

(7) Disappearance on exposure to the air. We have allowed blood to stand for 2 minutes, then made a film, and have not noticed any diminution in the numbers.

(8) Staining. With Romanowsky, they stain pink—a much deeper colour than the red blood cells, and sometimes the colour is nearly as deep as the magenta of the nuclei of the white blood cells. With Leishman's modification of Romanowsky they stain of exactly the same colour as the nuclei.

(9) Movement. These are not motile—not even amœboid.

CHAPTER V.

PHAGOCYTOSIS IN MALARIA.

There is probably no other disease in which phagocytosis can be so readily observed as it can be in malaria. DaCosta in his recently published book on Clinical Hæmatology says: "*Osler has observed the phagocytosis of crescentic forms, and the writer believes he has observed the result of this phenomenon in a single instance.*" While studying the crescents we have frequently put crescents under three microscopes and watched them for hours. The phagocytes would never attack immature crescents, nor crescents (male) before they threw out flagella, but when the flagella were thrown out, the chances were in favour of the phagocyte coming down and surrounding the flagella body.

From the large number of times that we have seen the phagocytes pass by crescents, without attacking them, we should be inclined to think that a phagocyte will never attack a crescent while it is still in the crescentic form.

We may here consider what cells are likely to act as phagocytes. The cell which is most commonly phagocytic is the polymorphonuclear. In the unstained specimen these are often irregular in shape and move across the field by amœboid movements. A projection of the sac or the protoplasm moves out, and the fine granules flow into this projection. We were not certain whether these cells were mononuclears or polymorphonuclears, for in the unstained blood it is difficult to distinguish these, but by taking a case in which there were large numbers of these phagocytes and then staining another specimen of the same blood we found, instead of the irregularly-shaped phagocytes, numerous more or less round cells with the typically stained nucleus of the polymorphonuclears. DaCosta states that "actual visual proof of the performance of this function by the mononuclears is wanting," although they show evidence of having acted the rôle of phagocytes. DaCosta states that the "mononuclears and polymorphonuclears alone exercise this function in the regularly intermittent fever."

We have watched the eosinophile cells to see whether they ever act as phagocytes, and have before us a series of drawings showing a Quartan rosette broken up, an eosinophile cell approaching, and finally surrounding and ingesting the rosette. It is, however, very rare to find the eosinophile cells acting as phagocytes. Coles quotes Kanthack and Hardy as being of opinion that eosinophile cells are not phagocytic, but we are convinced that their view is not correct.

We do not remember having seen an eosinophile attacking a flagella body. The common phagocyte will often pass by a broken rosette, but will rush to the attack when flagella begin to be thrown out.

EXPERIMENTS ON BENIGN TERTIAN.

The Benign Tertian experiments are shown in the accompanying table. Of four cases experimented on, three got Benign Tertian fever, and had Benign Tertian parasites in the blood. In one, Malignant Tertian parasites were found. During the time that these experiments were being carried out, only one other Benign Tertian case was found, so that the fact that three out of four of those who were bitten got Benign Tertian fever, and that out of about 1,100 men there was only one case of Benign Tertian, is fairly conclusive evidence that these men were infected by means of the mosquitoes.

EXPERIMENTS ON BENIGN TERTIAN.

Serial No.	Name. B	Name. A	Date when fed on A.	Number of bites.	Date when fed on B.	Number of bites.	Date when B was attacked by fever.	Kind of parasites found.	Degrees of fever.
	Dr. Joongay Lal, Hospital Assistant.	Ganda ...	8th Jan. '02 to 20th Jan. '02.	46	21st Jan. '02 to 25th Jan. '02.	20	4th Feb. '02	Benign Tertian parasites.	1·0, 6·3, 6·5, 0·0
2	Hari ...	Do. ...	8th Jan. '02 to 20th Jan. '02.	53	24th Jan. '02 to 27th Jan. '02.	2	....	......	......
		Narain (Double infection.) ...	15th Jan. '02 to 25th Jan. '02.	43	28th Jan. '02 to 10th Feb. '02.	14	15th Feb. '02	M. T. Rings ...	......
		Jairam ...	21st Jan. '02 to 26th Jan. '02.	10	30th Jan. '02 to 11th Feb. '02.	17	....	......	......
3	Jago ...	Do. ...	21st Jan. '02 to 26th Jan. '02.	27	30th Jan. '02 to 11th Feb. '02.	...	....	......	......
		Atumkhan ...	1st Feb. '02 to 13th Feb. '02.	38	15th. Feb. '02 to 25th Feb. '02.	12	23rd Feb. '02	Benign Tertian parasites.	1·0, 2·0, 2·0
		Tukaram ...	1st Feb. '02 to 13th Feb. '02.	55	15th Feb. '02 to 21st Feb. '02.	13	....	......	......
4	...	Do. ...	2nd Feb. '02 to 14th Feb. '02.	27	17th Feb. '02 to 22nd Feb, '02.	6	1st Mar. '02	Benign Tertian parasites.	4·0, 6·0, 6·0
			5th Feb. '02 to 15th Feb. '02.	88	17th Feb. '02 to 27th Feb. '02.	38	....	......	......

A.—The man on whom mosquitoes were fed primarily.
B.—The man who was bitten by the infected mosquitoes.

EXPERIMENTS ON MALIGNANT TERTIAN.

We had no difficulty in finding a case in which the sexual parasites were present, and therefore it was not difficult to get the anopheles infected. The dates, number of bites, &c., are shown in the accompanying table. Of five men who were bitten all got fever, and in all but one the Malignant Tertian parasites were found. The fever came 17, 20, 13, 19, and 22 days after the men were bitten. Out of about 1,100 men only one other was attacked by Malignant Tertian while the experiments were being carried out. There can then be no possibility of doubt that the mosquito carries malaria.

EXPERIMENTS ON MALIGNANT TERTIAN.

Serial No.	Name. B	Name. A	Date when fed on A.	Number of bites.	Date when fed on B.	Number of bites.	Date when B was attacked by fever.	Kind of parasites found.	Degrees of fever.
1	Fagoo ...	Mahadeo ...	25-12-01 to 8-1-02	22	10-1-02 to 17-1-02	19	27-1-02	M. T.	......
	Do. ...	Do. ...	28-12-01 to 7-1-02	42	10-1-02 to 20-1-02	23	......	......	3·4·5·5·0·3·0·0
2	Dewaji ...	Do. ...	11-1-02 to 23-1-02	37	24-1-02 to 26-1-02	3	... ..	......	......
	Do. ...	Do. ...	13-1-02 to 23-1-02	18	24-1-02 to 27-1-02	5	12-2-02	M. T.	1·4·0·2·0·0
	Do. ...	Do. ...	14-1-02 to 22-1-02	30	24-1-02 to 26-1-02	4	.. ...	......	......
3	Sukoo ...	Do. ...	24-1-02 to 4-2-02	136	7-2-02 to 19-2-02	82	19-2-02	*Nil.*	2·0·1·2·1·2·0
4	Bhondia ...	Do. ...	27-1-02 to 4-2-02	95	4-2-02 to 20-2-02	41	23-2-02	M. T.	3·7·2·5·4·6·2
	Do. ...	Do. ...	3-2-02 to 16-2-02	64	17-2-02 to 23-2-02	14	......	After 12 days Crescents found.	.. ...
5	Dasrath ...	Do. ...	29-1-02 to 11-2-02	94	12-2-02 to 23-2-02	45	3-3-02	M. T.	......
	Do. ...	Fagoo ...	26-1-02 to 9-2-02	65	12-2-02 to 21-2-02	26	......	After 8 days Crescents found.	2·3

A.—The man on whom mosquitoes were fed primarily.
B.—The man who was bitten by the infected mosquitoes.

EXPERIMENTS ON SPARROWS.

The sparrow experiments were made in March and April, and the increase in temperature may have influenced the development of the parasites. At any rate the parasites were found much earlier than they had been found in the experiments with human malaria. The proteosoma was found in one case on the 8th day and in one case on the 9th. The proteosoma is more easily conveyed than the halteridium. Out of three cases, in none did we fail to convey the proteosoma, while out of two cases in one we failed to convey the halteridium. This is curious, when we consider that the sexual forms are nearly always present in the sparrows affected with halteridium.

CHAPTER VII.

THE CONVERSION OF A SCEPTIC.

THERE is probably no more complete case to prove that the anopheles carry Malaria than that of Hospital Assistant Joongey Lal. Joongey Lal is a Senior Hospital Assistant, who has served the Government faithfully and well for many years, and who shortly expects to take his pension and retire. He has been watching with considerable interest the investigations that have been carried on in Nagpur in regard to Malaria, but the idea that the Malaria parasites are carried by mosquitoes sounded too absurd and ridiculous for a man of his long experience, to believe.

WAVERING.

He watched the dissections of mosquitoes that were made daily, and he saw that those which had been fed on Malaria cases presented certain differences from those which had not been fed on such cases. He had seen the little things that attach themselves to the wall of the mosquitoes' stomach (zygotes), and he had seen how day by day these grew larger: how they got outside the stomach wall: how after the 10th day a sort of fringe formed round these: and then a day or two later certain small bodies called sporozoites were found in the glands of the mosquito. He had seen many mosquitoes dissected, but in only those which had had an opportunity of feeding on Malaria blood were these sporozoites found. He began to think there might be something in it after all ; but he had seen several experiments made with a view to testing the truth of the mosquito-malarial theory, and he had seen many failures ; and here a word may be said about one cause of failure. When dissecting mosquitoes in the past cold weather we found zygotes frequently, but sporozoites we could not find at all until after we had tried the effect of keeping the mosquitoes in an incubator at a temperature of 80 F. The effect was marvellous—the zygotes grew bigger, and sporozoites were found in numbers. Therefore temperature plays an important part in the development of the parasites in the mosquito.

Well, the Babu saw all this, and he began to think that after all there might be something in it, and one day he said, " Give me fever and then I'll believe." What kind would you like, we said, and his reply was " Benign Tertian."

THE CASE FROM WHICH THE MOSQUITOES WERE INFECTED.

Here a slight digression may be made in order to say a few words about the case of Benign Tertian from which the mosquitoes were infected, because it was a case that many of the Members of the recent Malaria Conference had examined. On the morning of the 8th of January there was scarcely a parasite to be seen in any of the cases that were then in Hospital, but many of the Members of the Conference will remember that a man came to Hospital about the middle of the day, and that in his blood many parasites were found. Some of the parasites were giving out flagella, that is, they were in a suitable condition for infecting mosquitoes. Many anopheles were allowed to feed on this man, and several of these have been dissected since. Zygotes and sporozoites were found in due course, and when the sporozoites began to appear, Joongey Lal allowed the mosquitoes to bite him. He was bitten on the 21st, 22nd, 24th and 25th of January. It should be explained that his blood had been carefully examined before he was bitten and that no parasites were found. He was told that he would probably get fever between the 15th and 20th day after he had been bitten.

The Babu convinced.

On the 14th day (3rd February) he felt a little uncomfortable and his temperature was 99. One parasite was found after a long search. On the 16th day his temperature went over 104 and four parasites were found in 10 minutes. He saw these parasites himself, and as he is thoroughly familiar with the appearance of a Benign Tertian parasite, which cannot be mistaken for anything else, he was no longer a Sceptic, but a firm believer in the *fact* that mosquitoes carry the Malaria parasites.

Other experiments had been made and with similar results; but as there is more joy over one sinner that repenteth than over the ninety-and-nine who need no repentance, so it may perhaps have been excusable on the part of the Burmans who nursed the mosquitoes to rejoice over the conversion of the sceptical Babu.

It may be noted that the Members of the Royal Society's Commission saw the parasites both in the case from which the mosquitoes were infected and in the blood of Joongey Lal, and that they also dissected several of the mosquitoes which were fed on the first case. Joongey Lal refused to take quinine and allowed the parasites to have their own way for five days. His temperature went up over 104 on two occasions, and then being convinced beyond all possible doubt he took quinine, and stopped the fever.

One interesting point about this case may here be mentioned. A few days before the Babu got fever, Ko Tha Aung was asked whether he thought Joongey Lal would get fever. His reply was, "Undoubtedly, for all the mosquitoes from the batch that were allowed to bite Joongey Lal showed zygotes in the stomach or sporozoites in the glands."

We have a number of specimens mounted showing the parasites in the case on which the mosquitoes first fed the zygotes in the stomachs, the sporozoites in the glands and the parasites in Joongey Lal's blood.

CHAPTER VIII.

COLLECTING AND FEEDING MOSQUITOES.

MOSQUITOES for experimental purposes may be either bred from the larvæ, or be caught in a test tube after they have fully developed. The larvæ brought from the breeding pools may be sorted out and put in glasses or in bottles from which the tops have been removed. The bottles are much cheaper, and a very simple method of removing the upper part of the bottles may be described here.

Two strings are tied round the upper part of the bottle, leaving an interval of ¼ inch between them; a third string is passed round between these two, and by drawing the ends of this string with a sawing motion the glass becomes heated. When the glass is hot throw water on it, and the top drops off. Make a cover for the bottle with mosquito curtain stretched on a thin ring of wood.

The larvæ and nymphæ can be kept in these bottles. When the mosquitoes develop they can be easily removed by taking two pieces of thick paper, raising the cap and gradually inserting the two pieces of paper between the cap and the bottle, then removing the upper piece of paper with the cap. If we wish to kill the mosquitoes a drop of chloroform is allowed to fall through the mosquito netting on to the paper below, and the cap is covered for half a minute by the hand or another piece of paper. Chloroform vapour or tobacco smoke kills the mosquitoes in less than a minute.

For experimental feeding of mosquitoes the individual who is to be bitten puts his forearm, which may be previously moistened with water, over the mosquito curtain cap. The mosquitoes bite most readily just after sundown.

CHAPTER IX.

DISSECTIONS OF MOSQUITOES.

For dissecting mosquitoes the following articles are required :—

(1) A pair of fine forceps.
(2) Two mounted needles—or long ordinary triangular surgical needles.
(3) Normal salt solution ·7 per cent.
(4) A black and white board.
(5) A low power lens.

For our purposes only two dissections are required—one to expose the stomach and the other to expose the poison glands. The dissection to expose the stomach is easy, but before attempting to dissect a mosquito, it is well to starve it for two days so that the stomach may be empty, for it would not be easy to see the zygotes in a stomach which is full of blood. To expose the stomach: first remove legs and wings; fix the thorax with one needle; make a notch with the other needle on either side of the second last segment; draw the tail end slowly and gently from the rest of the body. The ovaries, five malpighian tubes, and the stomach are drawn out. Separate the ovaries and malpighian tubes. The stomach may be stained with methylene blue; carbol fuchsine will give some very pretty specimens, in which the muscular network comes out very clearly.

The method of dissecting out the glands which is usually described is rather difficult, but Ko Tha Aung found the following method very easy: Fix the thorax with one needle and put the other on the head, close to the eyes. Gently draw the head away from the thorax, and (N. B.) slightly forward. The glands come away with the head. Examine under a third power, and then separate the glands from the head with the cutting edge of the needle. Put on a cover-glass and squeeze gently. Sporozoites if present will be seen under a high power ($\frac{1}{7}$th).

It is advisable to keep the mosquitoes in saline solution after they have been killed and before dissection.

ZYGOTES IN THE STOMACH.

The parasite as seen attached to the stomach wall is called a zygote. It is the female malaria parasite after fertilization by the male. At first it is about the size of a blood corpuscle, and it is recognised by the presence of the pigment granules in it. If a number of mosquitoes are fed on a malaria case when the sexual forms are ripe and if one or two mosquitoes are dissected daily, it will be found that these zygotes are gradually getting larger, and the pigment gradually disappears. About the 6th or 7th day the zygotes show signs of division into parts or what have been called " meres. "

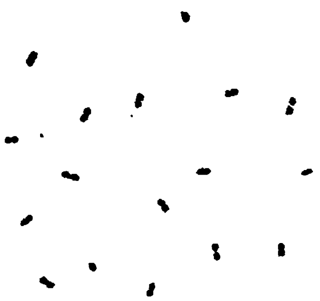
The zygotes gradually work their way out through the walls of the stomach, and under a low power ($\frac{1}{3}$rd) they can be seen as little knobs along the margins of the stomach.

A few days later a sort of frill is seen round the zygote. This frill is composed of enormous numbers

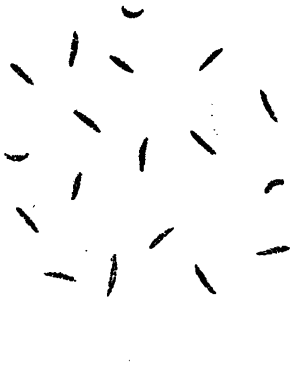
SPOROZOITES STAINED WITH ROMANOWSKY'S STAIN.

PLATE XII.

Malignant Tertian Sporozoites.



Benign Tertian Sporozoites.



of small spindle-shaped bodies. These are called sporozoites. They make their way up into the poison glands of the mosquito, and there remain until the mosquito has an opportunity of transferring them into their new host.

SPOROZOITES.

We have dissected many mosquitoes that had been bred from larva in captivity, but we have never found sporozoites in any of these mosquitoes which had not been fed on Malaria blood. How the sporozoites make their way from the stomach, whether by burrowing through the tissues, or by the blood vessels, we are not certain as we have not made sections of the mosquitoes, but about the 10th or 12th day the sporozoites will be found in the glands. In Culex which were fed on sparrows in the hot weather we have found the sporozoites in the glands twice on the 8th day and once on the 9th day. Probably temperature has some influence on the rapidity of development.

The sporozoites are curved spindles—that is, they are spindle-shaped but with a slight curve. But how do you know that these are in any way related to the parasites? This is a question that has often been asked. We have already traced the parasite into the mosquitoes' stomach, explained its growth, how it penetrates the stomach wall, how it divides, how the small spindles break away from it, and how these are afterwards found in the glands. But when we come to trace them beyond that we find there is a break. In many experimental cases the blood has been examined daily, after the infected mosquitoes have been allowed to bite, but for the first ten or twelve days, we have not been able to find any trace of the sporozoites in the blood. But if any one doubts the connexion between these sporozoites and the parasites, let him stain the parasites with Romanowsky's stain and compare the stained sporozoites with young parasites in the blood. In the centre of the sporozoites there is a small bit of chromatin which stains a brilliant red, and the remaining part stains blue. The young parasite when seen in the blood has got into the ring form, but its red and its blue indicate a strong resemblance between the sporozoite and the young parasite. Ko Tha Aung noticed that the chromatin in the Benign Tertian is larger in amount than in the Malignant Tertian.

In the following tables are shown the results of dissection of mosquitoes that were fed on Quartan, Benign Tertian and Malignant Tertian Cases. The details regarding the dissections were entered in a register which shows the following particulars :—

(1) Date when dissected.
(2) Date when mosquitoes fed on A (the case with Malaria .
(3) Number of days between feeding and dissection.
(4) Kind of anopheles.
(5) Caught in village or bred.
(6) Fed on what kind of fever case.
(7) Were flagella found at the time of feeding.
(8) Result of dissection (*a*) in stomach,
(*b*) in glands.
(9) Dates kept in incubator.
(10) Did mosquito die.

[illegible] batch al- [illegible]

[illegible] that are [illegible] have been [illegible] dissections [illegible] ere fed on [illegible]

[illegible] ED ON [illegible]

[illegible] LANDS.

[illegible]	Percentage in which sporozoites found.	Glands lost or spoiled in dissection.
[illegible]	2	3
[illegible]	16	1
[illegible]	0	3
[illegible]	0	0
[illegible]		...
[illegible]	...	...
[illegible]	0	0
[illegible]		...

[illegible] out of a [illegible] were found [illegible] ites were [illegible] it will be [illegible] mosquitoes [illegible] that are fed on blood containing either of the Tertian parasites. There are several factors which tend to make the percentage in the Quartan experiments very low. In the first place, it is very difficult to find a Quartan parasite giving out flagella—that is, it is difficult to find the parasites sexually ripe. A larger number of the mosquitoes used in these Quartan experiments were allowed to feed on blood in which the sexual forms were not found. There were at least 30 under this heading, and no zygotes or sporozoites were found in these.

DISSECTION OF MOSQUITOES WHICH WERE FED ON BENIGN TERTIAN CASES.

NAME OF MOSQUITO.	STOMACH.				GLANDS.			
	Stomachs successfully dissected.	Zygotes found in.	Percentage in which zygotes found.	Contained blood, or for some reason, could not be examined.	Glands successfully dissected.	Sporozoites found in.	Percentage in which sporozoites found.	Glands lost or spoiled in.
Fuliginosus ...	19	12	63	8	24	4	16	3
Stephensi ...	20	16	80	4	22	3	13	2
Culicifacies ...	13	7	50	3	16	2	12	0
Rossii ...	10	5	50	2	11	0	0	1
Listoni ...	0	0	0	0	...	..		...
Turkhudi ...	0	0	0	0	...	...		
Barbirostris ...	4	0	0	0	4	0	0	0
Total ...	66	40	...	17	77	9	...	..

Let us look at the number of mosquitoes that were fed on Quartan cases at a time when the sexual forms were ripe, and we find that in twelve such, zygotes were found in the stomachs while nine were blank. In only two did the sporozoites find their way into the glands. The comparative rarity of Quartan infection in this part of the country is partly due to the rare occurrence of the sexual forms and probably also to the difficulty of development in the anopheles. Dr. Christophers has found Quartan fever very common in the Duars; it will be important to enquire whether the Quartan sexual forms are more often seen there, or whether the mosquitoes found there are of a different species.

The species in which sporozoites were found were Fuliginosus and Stephensi.

In the anopheles, fed on Benign Tertian cases we found zygotes in 40 out of 66 stomachs, but 17 dissections were failures. It might be taken as a practical certainty that if a. Culicifacies, a. Stephensi, or a. Fuliginosus is fed on blood containing Benign Tertian parasites, when flagella can be seen, the zygotes can be found in the stomach. In the Rossii zygotes were found in only 50 per cent., and thereby hangs an interesting tale. Stephens and Christophers had noticed that Rossii were found in abundance in many places, *i.e.*, Calcutta, where malaria cases were not prevalent. Ko Tha Aung found zygotes in Rossii. and Dr. Christophers also found zygotes in Rossii. Later on Ko Tha Aung found sporozoites in one Rossii, but in the great majority of Rossii sporozoites could not be found. No doubt then the Rossii are very bad carriers of malaria. This is fortunate, for in Nagpur we found Rossii very abundant in the hot weather months, long after the other anopheles had become rare.

DISSECTION OF MOSQUITOES WHICH WERE FED ON MALIGNANT TERTIAN CASES.

NAME OF MOSQUITO.	STOMACH.				GLANDS.			
	Stomachs successfully dissected.	Zygotes found in.	Percentage in which zygotes found.	Contained blood, or for some reason could not be examined.	Glands successfully dissected.	Sporozoites found in.	Percentage in which sporozoites found.	Glands lost or spoiled in.
Fuliginosus	31	28	90	10	35	10	30	6
Stephensi	34	29	85	4	36	18	50	2
Culicifacies	38	31	82	7	39	13	33	6
Rossii	15	3	20	2	12	1	8	5
Listoni	2	2	100	0	2	0	0	0
Turkhudi	2	1	50	0	2	1	50	0
Barbirostris ...	4	2	50	0	4	0	0	0
Total ...	126	96	...	23	130	43	...	19

In the Malignant Tertian experiments the results are very similar to those in the Benign Tertian. The percentage of infection is, however, higher—90, 85, and 82 instead of 63, 80, and 50, but we were able to feed the mosquitoes on cases which we knew contained the ripe sexual forms in the blood Here, again, the Rossii showed themselves bad carriers, and in only one out of twelve were the sporozoites found in the glands. Sporozoites were, however, found in another after the above table was prepared.

CHAPTER X.

THE EGGS OF ANOPHELES.

THE reader who is concerned with the purely practical part of the subject of Malaria will not perhaps find much important matter in this Chapter: to those who are interested in the natural history of the subject the study of the eggs cannot fail to be attractive. The eggs of the anopheles are laid separately, and this gives at once a method of distinguishing them from all kinds of culex eggs. They are seen as tiny black specks on the surface of the water. They may be collected by drawing a piece of paper along the surface of the water. For examination we usually obtained them by putting a piece of wetted paper in the inverted wide-mouthed bottles in which the mosquitoes were kept. The paper was placed on a thin piece of cork which was floated on water. The anopheles laid their eggs on the paper.

If we examine the egg of a Rossii with a low power (a third) we see an appendage on either side which is called the float, and as we screw the microscope down we see the frill, which in the egg of Rossii goes almost completely round the egg.

The eggs of one species differ from those of another species, and from an examination of the egg it is in most cases easy to tell to what species an egg belongs. The photograph is taken from drawings that were made with the aid of the camera lucida by the Burmans. Microphotographs were taken of groups of eggs of most of the species, and the drawings were corrected so that they give a very fair idea of the appearance of an egg as seen under a low power.

The eggs of the eight species which are shown in the photograph are arranged in a series according to the size and appearance of the frill, which in the Rossii (at the top of the photo.) completely surrounds the egg, and in the Turkhudi (at the bottom) has almost disappeared. Notice how the frills in the Fuliginosus. Jamesii and Stephensi nearly meet in the middle. Further down the middle parts of the frill have disappeared—in the Theobaldi, and as already pointed out we see the mere remnant in the egg of the Turkhudi—that anopheles which is a sort of connecting link with the culex group of mosquitoes.

When reading the following brief descriptions please refer to the photograph.

(1) The egg of the Rossii is large and has a wide surface ; the frill goes round the egg, excepting a little bit at either end ; the floats are very large.

(2) The egg of the Barbirostris is rather like that of the Rossii, but when turned on its side, it shows turned up points at the ends.

(3) The egg of the Fuliginosus has also a wide surface, but the frill does not extend quite round the egg. There is an interruption at the place where the floats come.

(4) The egg of the Jamesii is very much like that of the Fuliginosus.

(5) In the Stephensi egg the floats almost meet in the centre.

EGGS OF ANOPHELES.

The first three pictures are microphotographs of eggs taken under a third power microscope. The difference in colour is partly due to a difference in the lighting. The Rossii egg was taken more under transmitted light: the Culicifacies egg more under reflected light.

Fig. 1—Egg of Rossii : the float and fringe do not come well into focus together at the same time, but the egg on the top shows the frill though indistinctly.

Fig. 2—The eggs of Culicifacies : notice the frill forming two almost parallel lines.

Fig. 3—The eggs of Theobaldi : there was not quite enough reflected light to show up the great beauty of these eggs.

Fig. 4—This picture is a photograph of drawings of eggs. They are arranged in a series to show the frill going round the whole egg : the frill closing in towards the centre of the egg : the frill forming two separate ovals at either end of the egg (Theobaldi) : and the mere remnant of the frill in the Turkhudi. Note that the float is absent in the Turkhudi.

1.—Rossii.
2.—Barbirostris.
3.—Fuliginosis.
4.—Jamesii (true).
5.—Stephensi.
6.—Culicifacies.
7.—Theobaldi.
8.—Turkhudi.

LARVÆ.

On the left are :—

Fig. 5—A group of Culex larvæ in a glass box.

Fig. 6—A group of Anopheles in a glass box. The two sheets of glass in the box are close together; hence the surface of the water is somewhat irregular.

Fig. 7—Turkhudi in a glass box.

Fig. 8—The photo on the right shows three groups of larvæ : they were in egg cups and the photo was taken from above. The largest larvæ are Barbirostris and the pretty markings on the back are very well shown. Below these is a group of Rossii. Note how these two get on parade around the side of the egg cup. On the right are the Turkhudi scattered irregularly about.

(6) In the Culicifacies egg the frill runs along the whole length of the body.

(7) The egg of the Theobaldi is a very distinctive one and is remarkable for its great beauty. The frill is divided into two parts, each of which forms an oval on either end.

(8) The Turkhudi egg is the last of the series. In it there is a rudimentary frill at one end. This egg sinks in water for it has no float.

We were not able to obtain the eggs of Listoni for they would not lay in captivity. The Barbirostris also would not lay, but by a modified Cæsarean section we were able to obtain a few eggs.

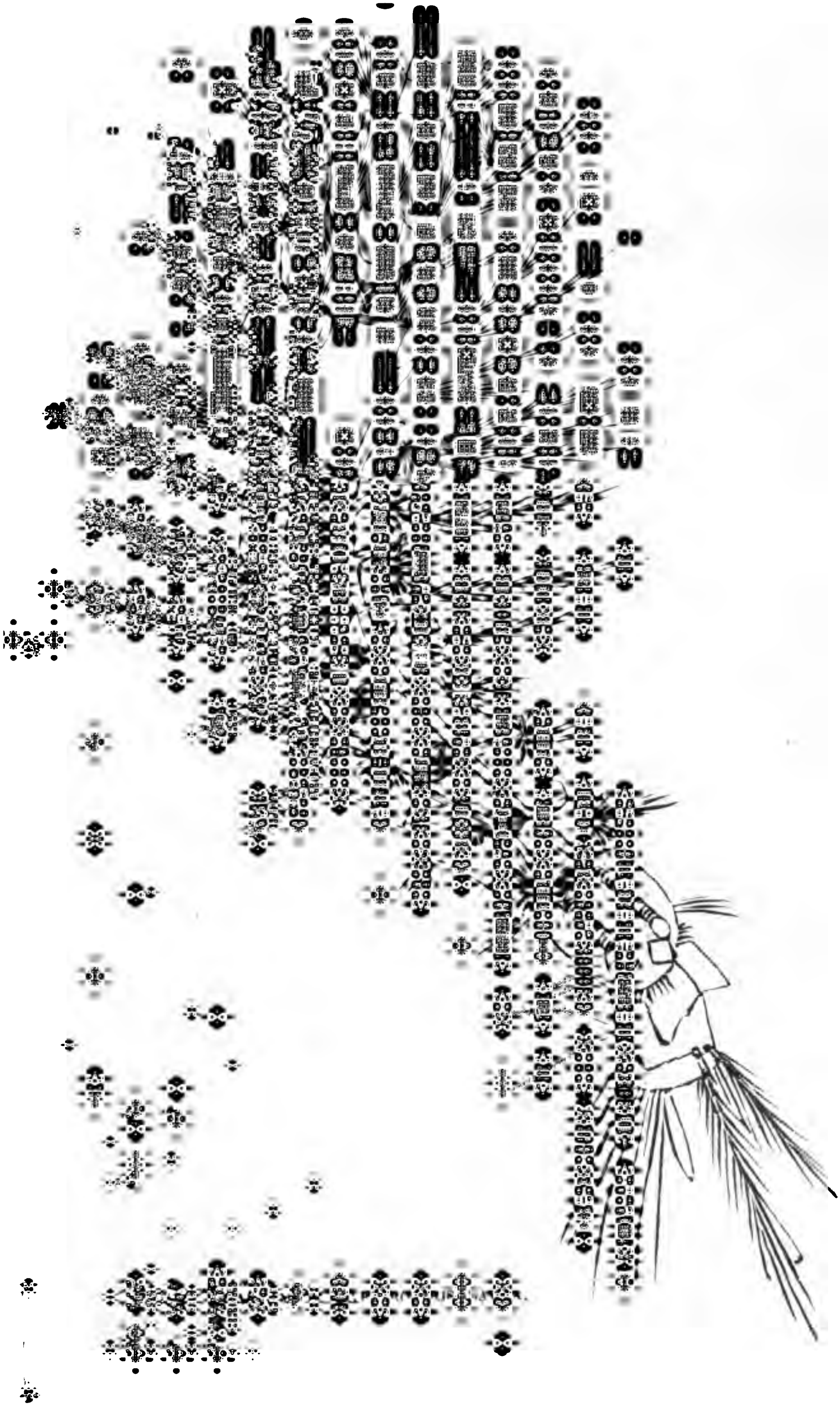
CHAPTER XI.

ANOPHELES LARVÆ.

SOME NOTES ON THEIR MICROSCOPIC CHARACTERS.

During the visit of the Royal Society's Commission to Nagpur and during the Malaria Conference which met at Nagpur early in 1902, a good deal of attention was given to the microscopical characters of the different kinds of anopheles larvæ. We are indebted especially to Dr. Christophers, Captain James, I.M.S., and Captain Glen Liston for a good deal of the information which is contained in this chapter. Ko Tha Aung and some other Burmans have, however, been working at the differential characters since, and have prepared from photographs and camera lucida drawings most of the illustrations which are given below.

A larva, which to the naked eye does not appear to be an object of any very special interest, becomes at once an object of the greatest interest when looked at through a low power microscope, and this interest is much increased when we compare the larvæ of different species. The accompanying drawing shows a larva of one of the anopheles—Barbirostris. The first thing that strikes us when looking at the head is a number of hairs, many of which are branched. Most of these project forwards, and if nature had ever intended that the motion of the larva through



the water should be with its head foremost, the arrangement of these hairs would have been a source of great inconvenience. But it is well known that the larva moves through the water with its tail in the direction in which it is going.

At the front of the head there are two bunches of hairs, one on either side, forming what are called the feeding brushes and, as we watch the larva in the water, we see that these are in almost constant motion apparently drawing into its mouth the particles of food on which it subsists. These feeding brushes in most of the larvæ project forwards, but in one species (Turkhudi) they are placed transversely. It will be shown later on that this species which is called after a Native gentleman in Bombay, who has made some very beautiful drawings of mosquitoes for Captain Glen-Liston, not only has the brush placed transversely but that unlike other anopheles larvæ it has a black tip to its proboscis, and it often hangs in the water with its head down, a position that no other anopheles larva takes.

FRONTAL HAIRS.

The next point that attracts our attention is the frontal hairs. These are four hairs that project forwards from the front of the head—two on either side. When looking for these take care that the hairs which project forward from the thorax are not mistaken for the frontal hairs. The two hairs nearer the middle line are called the central frontal hairs and the other two, the side frontal hairs. These hairs vary considerably in the different species, and an examination of them helps us to distinguish one species from another. The various arrangements may be represented by the following four diagrams :—

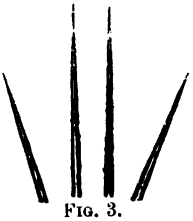


Fig. 3.

(1) Both hairs simple and unbranched. This is the arrangement found in Culicifacies, Listoni, Rossii, Stephensi and Turkhudi. In Theobaldi the side hairs appear to be unbranched under the low power, but under a high power they are seen to be slightly branching.

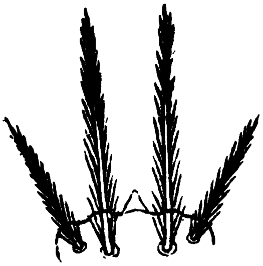


Fig. 4.

(2) In the true Jamesii both hairs are equally branched.

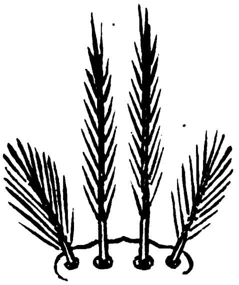


Fig. 5.

(3) In the Fuliginosus the central hairs are branched, but the side hairs are more like a palm leaf.

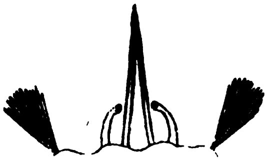


Fig. 6.

(4) In the Barbirostris the central hairs are unbranched, but the side hairs are large and form what has been called a cockade.

mbs are the next
on may be direct-
the side of the
sides are slightly
ends they are
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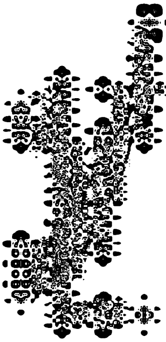

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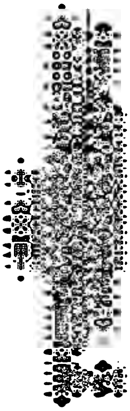

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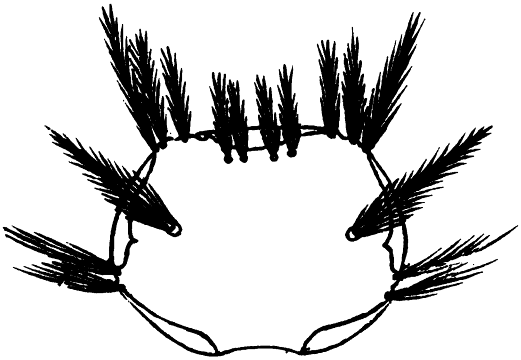

FIG. 10.—THORAX OF CULICIFACIES.

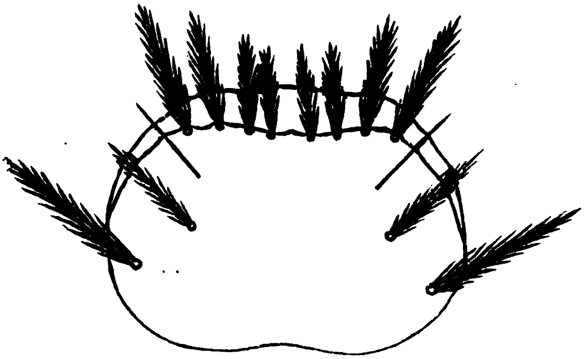

FIG. 11.—THORAX OF ROSSII. HAIRS.

The so-called palmate hairs might have received a more suitable name, for they are not in the least like hairs. They are like miniature leaves of a certain kind of palm tree and are attached, one on either side of each segment of the larva. These apparently are for the purpose of keeping the larva floating. This view is borne out by the fact that the Turkhudi which hangs with its head down, has no palmate hairs on the first three segments, and also by the fact that the Culex, which hangs more nearly vertical than the Turkhudi, has no palmate hairs.

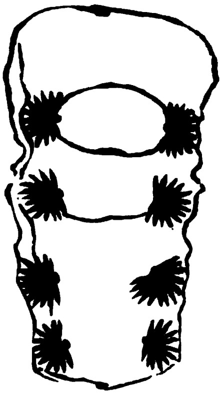

FIG. 12.

The illustration is a diagrammatic representation of the palmate hairs on segments.

PALMATE HAIRS.

These palmate hairs vary considerably in the different species, and they may be useful in helping us to distinguish one species from another.

In examining these hairs the points to be looked at are (*a*) the blade, (*b*) the point, (*c*) the shoulder, (*d*) the serrations on the point.

(*a*) *The blade.* The number of blades varies not only in the different species, but also in the palmate hairs on the different segments. The blades in some are narrow, while in others they are broad : in some they are shaded dark, while in others they appear to be almost transparent.

(*b*) *The point.* In some the point is long, while in others it is short : in some it is sharp, while in others it is blunt.

(*c*) *The shoulder.* In some the blade tapers into the point, while in others the blade ends more or less abruptly forming a shoulder, where the leaf joins the point.

(*d*) *Serrations.* In the Barbirostris the point is serrated.

The illustrations below were taken from drawings which were made by Ko Tha Aung with the aid of the camera lucida. The first five have long blades and long points. Then comes one with a long blade and short point. Then follow those with short blades and short points.

Diagrammatic representation of Palmate Hair Leaves of different Species.

Barbirostris : the largest palmate hair : point serrated.

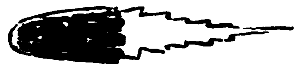

Fig. 13.

Rossii : long narrow blade and long point.

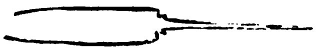

Fig. 14.

Culicifacies : shoulder serrated.

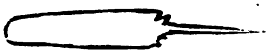

Fig. 15.

Listoni : blade shaded : long thin point.

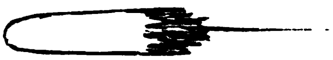

Fig. 16.

Fuliginosus : broad blade : point sometimes long, sometimes short.

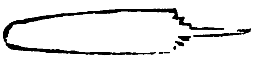

Fig. 17.

Stephensi: long blade, short point.

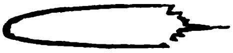

FIG. 18.

Jamesii: short blade and short point

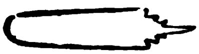

FIG. 19.

Theobaldi: short blade, short point.

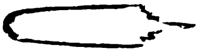

FIG. 20.

Turkhudi: short blade, point blunt.

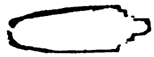

FIG. 21.

The table (overleaf), which gives a summary of the main points, has been prepared by Ko Tha Aung.

It should be noted that in three species, Barbirostris, Listoni, and Culicifacies, there are palmate hairs on the thorax; also the palmate hairs on the first segment are different from those on the other segments and they do not show the typical markings.

The photographs in Plate II will help the reader to get a clearer idea of some of the points mentioned in this Chapter. In Plate I, Figures 5, 6, 7, show larvæ of culex, anopheles, and Turkhudi in water. The first two are nearly of the natural size, but the Turkhudi is about half the natural size. Note how the culex hang obliquely under the surface of the water and note the long breathing tube at the tail end. The anopheles lie almost horizontally under the surface. The Turkhudi takes up an intermediate position.

In Plate I, Fig. 8, are shown some anopheles larvæ in egg cups and viewed from above. They are about two-thirds of the natural size. The large ones prettily marked are Barbirostris. Below these are some

Name.	Frontal Hairs.		Palmate Hairs.					Thorax hair.	Any special marks.
	Central.	Lateral.	Blade.	Points.	Shoulder serrations.	No. of blades.	On thorax.		
Listoni ...	Simple parallel.	Simple	Long thin.	Very long	Deep	20 to 22	Yes	Large	Largest palmate hair on a small larva.
Culicifacies ...	Do.	Do.	Long, broad.	Long	Medium	16 to 18	Yes	Largest	Largest thorax hair.
Rossii ...	Do.	Do.	Long, thin.	Very long	One or none	16 to 18 10 on last.	No	Smallest	Very long palmate with small thorax hair.
Stephensi ..	Do.	Do.	Do.	Short	Deep, 3 or more.	16 to 18 10 on last.	No	Rather small.	Palmate hair, long blade, short point.
Turkhudi ..	Do.	Do.	Short broad.	Very short and blunt.	1 or 2	12 to 14	No	Medium	Feeding brush horizontal; no palmate hairs on first three segments.
Barbirostris ...	Simple converging.	Cockaded	All serrated.	...	Do.	20 to 23	Yes	Small	Serrated palmate hair on comb.
Jamesii (trub) ..	Branched	Do.	Rather short & broad.	Short	Deep, 3 or more.	14 to 16	No	Large	Four frontal hairs equally branched.
Fuliginosus ...	Do.	Do.	Do.	Do.	Do.	16 to 19	No	Do.	Frontal hairs branched lateral cockaded.
Theobaldi ...	Slightly branched	Slightly branched	Short & broad.	Short, sharp, sometimes blunt.	Do.	16 to 19	No	Do.	Short palmate hair.

Rossii, and on the right are few a Turkhudi and it will be noticed that they do not take up a regular position, on parade, around the side of the vessel, like all other anopheles. They often hang with their heads down, and consequently in the photograph they appear more or less as a blur.

PLATE II, FIGS. 9, 10, 11, HEADS OF LARVÆ (MICRO-PHOTOS) BARBIROSTRIS, FULIGINOSUS AND TURKHUDI.

The feeding brushes.—The feeding brushes are seen in Fuliginosus and Turkhudi. Notice the transverse position in the Turkhudi. The feeding brush in the Barbirostris happens to have been moved down at the time the photo was taken, and is consequently not seen. The frontal hairs are well seen in the Barbirostris. Notice the unbranched central hairs lying close together and the large cockades at either side. The central frontal hairs are well seen in the Fuliginosus, but the slightly cockaded side frontal hairs can scarcely be seen as they lie over the feeding brush.

Plate II, Fig. 12, Photos of drawings of five heads. The feeding brush is represented in outline in all but the Turkhudi.

Plate II, Fig. 13, Photo of drawings of the palmate hairs arranged in a series to show the gradual transition from the large palmate hair of Barbirostris to the diminutive one of Turkhudi.

HEADS OF ANOPHELES LARVÆ.

Fig. 9—Microphotograph of the head of a Barbirostris larva showing well the lateral frontal hairs or cockade: also showing the branching hair on the comb.

Fig. 10—Microphotograph of the head of Fuliginosus larva showing the brush and the central and lateral frontal hairs.

Fig. 11—Microphotograph of the head of a Turkhudi larva showing the transverse position of the feeding brush.

Fig. 12—Photograph of drawings of the heads of five different kinds of larvæ. The drawings were made with the aid of the Camera Lucida, but they are semi-diagrammatic. The feeding brush is shown in outline except in the case of No. 3—the Turkhudi.

(1)—A. Stephensi: four frontal hairs are simple. The centre space darker and larger.

(2)—A. Fuliginosus: central frontal hairs branched, lateral frontal hairs cockaded.

(3)—A. Turkhudi. Note the horizontal feeding brush.

(4)—A. Listoni: simple frontal hairs. It has a long and thick "*crack*" line extending nearly to the comb.

(5)—A. Culicifacies: frontal hair simple, the centre space very small and light.

PALMATE HAIRS.

Fig. 13—Photographs of drawings of the palmate hairs. They are arranged in a series beginning with the large palmate hairs of Barbirostris and ending with the diminutive palmate hairs of Turkhudi.

1.—Barbirostris.
2.—Rossii.
3.—Listoni.
4.—Culicifacies.
5.—Fuliginosus.
6.—Stephensi.
7.—Theobaldi.
8.—Jamesii (true).
9.—Turkhudi.

Fig. 14—A microphotograph of part of the body of a larva of Barbirostris showing two palmate hairs and part of three segments of the body.

Fig. 15—Microphotograph of a filaria found in some anopheles larvæ in Nagpur.

CHAPTER XII.

MISCELLANEOUS NOTES ON LARVÆ AND NYMPHÆ.

(Naked-eye appearance.)

We have heard it said by men who have devoted much time to the study of mosquitoes and their larvæ, that it is not possible to distinguish the larvæ of one species from another by the naked eye. The men we have assisting us are able at present to separate out the larvæ of the different species with considerable accuracy. If you have before you a series of glasses containing about 50 of each species of larvæ, you will at once see that there are considerable differences between the species, but it required a considerable amount of work before we were able to find out what are the distinguishing marks of each species, and having found them out there still remains the difficulty of giving a description of the distinguishing points.

A short account of the method by which the distinguishing marks of each species were found out may be useful to others who are working at this subject. We noticed that some of the larvæ had a white line running along part of the back, and these were picked out and kept in a separate glass. They were called silver backs. As the mosquitoes hatched out they were killed and examined, and from this glass we found mostly Fuliginosus and Jamesii, though occasionally a Rossii would be found among them. Afterwards we noticed that the silver streak on the Rossii was not so distinct as it is in the Fuliginosus, and that it is not always present. Then we separated out those with a black band across the back, but from these, which we called "black backs," two or three species hatched out, so this mark was of little use for purposes of distinction. Some showed a yellow mark round the neck, and these most often came out Culicifacies, but this did not give a distinctive mark, and we had to search for some other marks. By working on in this way we were able finally to find the marks by which one species could be fairly well distinguished from another, and these marks are given below.

MARKINGS OF LARVÆ.

(1) *Culicifacies.*—Small, two whitish or yellowish rings, one round the neck and one on the fifth segment. The men who sorted them called them Double rings.

(2) *Fuliginosus.*—Size about the same as Culicifacies, Jamesii and Listoni. It can generally be distinguished by a silver streak running down the back to the fifth segment.

(3) *Jamesii.*—Like Fuliginosus, but no white line along the back.

(4) *Stephensi.*—Light brown body and dark head (cobra head). Same size as Rossii and liable to be mistaken for it.

(5) *Rossii.*—Light brown body and dark head (dark cobra heads) : thorax large : sometimes a white line is seen on the back running to the fourth segment, but the line is only seen in a bright light.

(6) *Listoni.*—Very thin body, dark line along the back.

(7) *Barbirostris.*—The largest larva : easily distinguished by the white marks on the back (see photo). The colour varies considerably, sometimes being dark brown, sometimes light brown, sometimes reddish. They very often assume a bent position, and especially if you touch the vessel in which they are.

(8) *Turkhudi.*—A stout larva : it occasionally lies horizontally under the surface, but usually it lies with its head a little way under the surface (see photo). Other anopheles if put in a glass, arrange themselves around the side of the glass like well-drilled soldiers. The Turkhudi never get into a regular line, but lie irregularly here and there (see photo). The Turkhudi has no palmate hairs on the first three segments.

(9) *Nigerrimus.*—A large larva with a big head.

(10) *Theobaldi.*—Size same as Jamesii and Fuliginosus : silver back with a white ring behind the thorax.

BREEDING PLACES OF ANOPHELES.

If one species carries Malaria better than another species it becomes a matter of practical importance to find out the nature of the breeding places of the different kinds of larvæ.

For the past five months (November to April) we have had a small party of men collecting anopheles larvæ daily, and they know now very well in what sort of place to find particular kinds of larvæ. Some of the larvæ have not much choice as to their breeding place, but others are evidently very particular and are only found in special places. The Culicifacies and the Rossii are easily pleased and will breed in almost any kind of water. The Culicifacies shows a little more choice than the Rossii, but the latter will sometimes be found in foul smelling and dirty water. The Jamesii is fond of very clear water, and the Listoni appears to be the most particular of all in this respect, for it chooses water which is a near approach to spring water. The Stephensi also prefers very clear water.

The surroundings apparently also have some influence. For instance, the Barbirostris larvæ have been found only in one place, that is in a stream which runs through the Maharaj Bagh, where there are many trees overhanging the stream and many decaying leaves in the bed of the stream. The Fuliginosus was found in some small streams a few months ago, but now (in April) they are only to be found in a large tank (Tellinkerry) in which the water is fairly clear. The Turkhudi is found only in pools by the side of streams, *i.e.*, it seems to object to running water.

Anopheles will breed also in the pots, tins, or tubs near the bungalow. A favourite place is the small tank in which the water from the bath-room collects. In the tank in which the water from the cook-house collects culex are often found in abundance, but anopheles as a rule avoid such water as it is frequently foul smelling.

We often find a pool of a few yards diameter in which there are no larvæ in the main body of the water, but in cattle tracks at the side of the pool, anopheles larvæ may be abundant. It is well to remember this when killing larvæ by putting kerosine oil on the pools.

A FILARIA FOUND IN SOME ANOPHELES LARVÆ.

While examining larvæ Ko Tha Aung noticed that some of them looked rather fat and sluggish. He could see nothing to account for this when examining them in the ordinary way under the microscope, so he turned them upside down and examined them through the under surface. The larva was put on a slide in a drop of water and the slide was put on the stage of the microscope with the water and larva on the under surface. A filaria was then at once seen. It appeared to occupy the whole cavity of the body.

To demonstrate this filaria more clearly a small opening is made in the body of the larva with dissecting needles, and if the larva is placed in a weak solution of methylene blue the filaria will stain a pretty blue colour and at the same time die. We have been able to mount a number of specimens showing the larva partly inside and partly outside the body of the larva. (See Plate II, Fig. 15.)

What is the fate of the larva which is thus infected and what becomes of the filaria? A number of the infected larvæ were kept in a bottle for some days. All the infected larvæ died; while in the bottom of the bottle the filariæ could be seen in bunches with the naked eye.

These filaria are nearly half an inch in length, or about one-third the size of the filaria which one finds in the eye of the horse.

Dr. Lingard, of the Muktesar Laboratory, who has given a good deal of attention to the study of filaria saw these when recently visiting this Laboratory and thought that they had not been already described.

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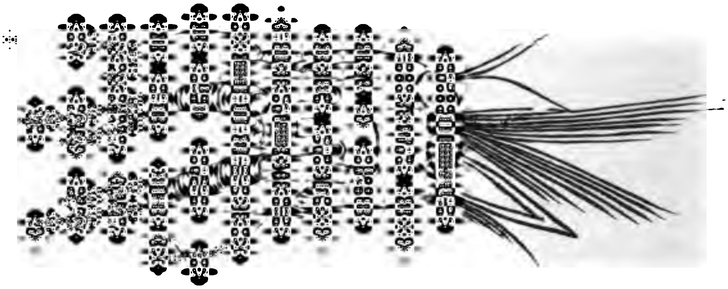
[illegible] guish the different [illegible] age, but in some [illegible] of the larvæ, which [illegible] can be seen in the [illegible] rostris nympha is [illegible] by its size and the [illegible] ery interesting to [illegible] a into the nympha. [illegible] in the skin behind [illegible] kicks" and breaks [illegible] s the body. The [illegible] the palmate hairs, [illegible] The most curious [illegible] in the breathing [illegible] through two tubes [illegible] of the back and



[illegible]

[illegible] e nympha there are [illegible] sses reminding one [illegible] 'spathe," and the [illegible] ocesses.

The anterior part of the body is coiled up into a sort of ball, and the tail end projects out from behind and below. The nympha moves by a series of jerks of the tail, but they stay more at the surface than the larvæ, and they do not go down to the bottom to feed as the larvæ do. They may go down to the bottom of the glass for a short time if they are disturbed.

CAHPTER XIII.

MOSQUITO ANATOMY.

Before attempting to classify the anopheles it is necessary to know a few details in regard to the external anatomy. We shall only refer to those parts which are looked at for the purposes of classification, and a reference to the accompanying illustrations will show the names applied to the principal parts of the mosquito. But to correct erroneous impressions that may be conveyed by these diagrammatic illustrations, those who have the opportunity should examine a real mosquito at the same time.

The classification which follows in the next chapter is based on the markings which are seen on the female. The bushy antennæ of the male enable us at once to distinguish him from the other sex.

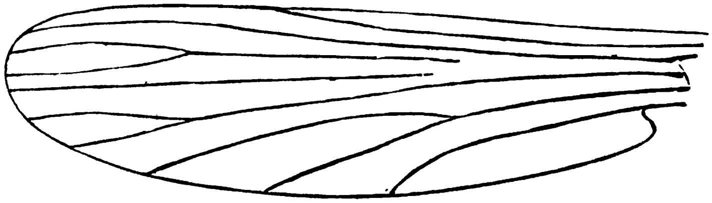
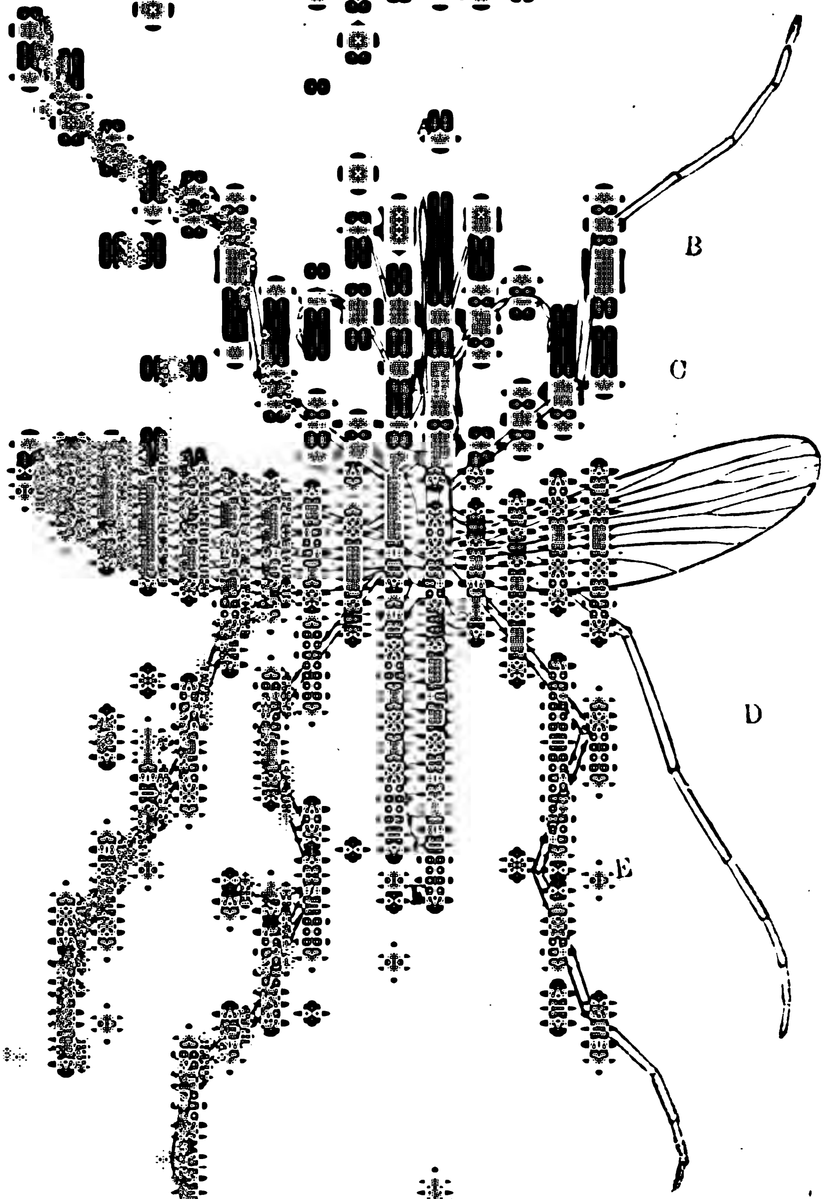


Fig. 23.—Wing.

In the wing there are seven veins. The first counting from above is called the subcostal, and the others are numbered from above down, first longitudinal, second longitudinal, &c. Note that the second, fourth and fifth bifurcate. The third is for our purpose



[illegible], wings; D, middle
[illegible]

the most important. In the Listoni it is light in colour, while in the Culicifacies it is dark.

The hind leg is composed of coxa, trochanter (not shown in the diagram), femur, tibia, five segments, and a claw at the end of the fifth segment.

The proboscis is an elaborate structure with stylet and sheath (not shown in the diagram). On either side are the palpi, which generally lie close to the proboscis, but which are separated in the diagram from it. The antennæ lie outside the palpi.

CHAPTER XIV.

CLASSIFICATION OF ANOPHELES.

We found it a very difficult or impossible task to name any anopheles as long as we took the wing markings as a guide. Captain Glen Liston, I.M.S., then showed us his method of classification, and we found that what had been a very difficult subject before was at once converted into a very simple one.

This classification is based on the markings of the palpi, and the anopheles are divided into three groups according to the appearance of the palpi : A. Unbanded ; B. with four bands ; C. with three bands on the palpi.

Some of these divisions are again divided according as the ends of the palpi are white or black. The majority fall into the group with three bands on the palpi and white tips.

Then we examine the legs, and we find that those with three bands and white tips can be divided into three sub-groups :—I—Legs unbanded ; II—Tips of hind legs white ; III—Tarsi banded.

Then it may be necessary to look at the wings, and what is called the third longitudinal vein is the main point to which attention may be given in the wing. This is black in the Culicifacies and white in the Listoni.

So by looking at the (1) bands on the proboscis, (2) the tip of the proboscis, (3) the markings on the legs, and (4) the third longitudinal vein in the wing, we are able with the classification in front of us to identify any of the more common species in a few minutes.

The classification given below is a slight modification of that which was drawn up by Captains Liston and James. For simplicity a number of the less common anopheles have been omitted. For their classification in detail, see Transactions of Malaria Conference).

A	Palpi : unbanded.	I	Lindesayii :	tarsi unbanded.
		II	Barbirostris :	tarsi banded.
B	Palpi : 4 banded.	I	Pulcherrimus :	tip of hind legs white.
		II	Nigerrimus :	„ „ black.
C	Palpi : 3 banded	I	Turkhudi :	tips of palpi black.
		II	A large number have tips of palpi white.	

The 3 banded with white tips are as follows :—

(1) Legs unbanded :

1. Culicifacies :	third longitudinal black.
2. Listonii :	„ „ white.
3. Fluviatilis :	half „

(2) Tips of hind legs white :

(1) Theobaldi : 2¼ hind segments white : tibiæ and fibulæ speckled.

(2) Fuliginosus : (false Jamesii) 3¼ hind segments white : palpi have one broad on 2 narrow bands.

(3) True Jamesii : 3¼ hind segments white : palpi have two broad on one narrow band.

(3) Tarsal joints banded :

(1) Rossii : large white band on two small bands : tibiæ and fibulæ unspeckled.

(2) Stephensii (speckled Rossii) : 2 broad bands on 1 narrow band : tibiæ and fibulæ speckled.

HEADS OF ANOPHELES.

THE first of these is a photograph of a drawing made with the aid of the Camera Lucida. The others are microphotographs. The palpi have been slightly separated from the proboscis in some of the heads.

Fig. 16—Head of A. Barbirostris: very large, hairy and all black.

(The next three heads, Figs. 17, 18 and 19, show one broad terminal band on two narrow bands.)

Fig. 17—A. Culicifacies: small and not hairy or only slightly hairy.

Fig. 18—A. Rossii and Fig. 19 A. Fuliginosus: hairy, the former tends to gray and the latter tends to black in colour.

(Photographs to show the two broad terminal bands on one narrow band.)

Fig. 20—A. Stephensi and Fig. 21—A. Theobaldi: in addition to the three regular bands, there is some speckling, at different levels on the two palpi, almost forming a fourth band.

Notes.—The following have the tips of the hind legs white : —Pulcherrimus, Theobaldi, Jamesii, Fuliginosus.

Those with two broad bands on the palpi have speckled legs, *viz.*, Jamesii, Stephensii, Theobaldi.

When examining mosquitoes use a black and white board, and use first one side and then the other as a background. The black tips of Turkhudi do not show up against a black ground. The white hind legs are not easily seen against a white ground. The speckled legs of a Stephensii are seen more clearly against a black background.

Liston and James have shown that all those with the three-banded palps are domestic species; that two of those with unbanded palpi are Hill species (Lindesayii and Gigas). They also show that the Barbirostris, Nigerrimus and Pulcherrimus are wild species. In this connexion we may say that, although we found large numbers of Barbirostris larvæ in the stream which runs through the Maharaj Garden at Nagpur, and although search was frequently made for the fully developed mosquito, only one was found. Most of the mosquitoes bred from the larvæ in captivity would lay eggs, but the Barbirostris could never be persuaded to oblige us in this respect.

CHAPTER XV.

EXPERIMENTS WITH METHYLENE BLUE.

We often meet people who say that they cannot take quinine. In some it causes considerable discomfort. In pregnancy it should be given with great caution, and, if given at all, it is well to leave a dose of opium with the patient to be taken in case the quinine should cause contractions of the uterus.

Methylene Blue is a valuable substitute in such cases, as will be seen from the following experiments on 4 Quartan, 15 Benign Tertian, and 2 Malignant Tertian Cases.

In Quartan Cases.

The experiments were begun with Quartan fever, and in the first case only one grain was at first given. After two paroxysms one grain of Methylene Blue was given, and next day another grain was given. There was no decrease in the fever. After two more paroxysms two grains were given. Two paroxysms followed, but the second of these was very slight. The parasites were reduced in number, but a few remained.

Case II.—The effect of the Methylene Blue will be seen in the following abstract from the chart which shows the degrees of fever—F., the number of parasites found daily; P and the amount of Methylene Blue given M. B. :—

Fever	**2**	**0**	**0**	**5**	**0**	**0**	**4**	**0**	**0**	**0**
Parasites	3	3	3	8	3	3	6	6	0	0
M. Blue	0	0	0	3	3	0	3	0	5	10

The three-grain doses were not sufficient to stop the fever.

Case III.—After 20 paroxysms, four grains were given on the 7th June. On the 9th and 11th the dose was repeated: fever stopped, and the parasites were reduced to about one in each examination.

Case IV.—But six weeks later the fever again returned. Three grains were given before an expected attack. The paroxysm came on. On the three following days 3, 4, and 5 grains were given. The fever stopped and parasites gradually disappeared.

Remarks.—One grain has very little effect. Three grains are not sufficient. Four grains daily may stop the fever, but larger doses are probably required to stop it with certainty.

IN BENIGN TERTIAN.

The charts may be divided into three sub-groups, *viz.*, ten in which the Methylene Blue seemed to have a marked effect, three in which the effect was not so marked, and two in which the action of the Methylene Blue was still less decided.

Taking the first ten we find the results as follows :—

(1) Fever	6	6	0	1	0	0	0
Parasite	8	6	2	0	0	0	0
M. Blue	0	0	6	6	6	0	0
(2) F.	4	0	0	0	0	0	0
P.	4	4	0	0	0	0	0
M. B.	0	6	6	6	0	0	0

(3) Fever	4	0	0	0	0	0	0
Parasite	12	6	2	0	0	0	0
M. Blue	0	0	6	6	6		0
(4) F.	2	3	5	0	1	0	0
P.	3	4	5	5	0	0	0
M. B.	0	0	0	6	6	6	0
(5) F.	3	0	5	0	0	0	0
P.	1	2	4	2	2	0	0
M. B.	0	0	0	6	6	6	0
(6) F.	4	2	4	1	0	0	0
P	5	25	38	21	3	5	0
M. B.	0	0	6	6	6	6	6
(7) F.	4	0	0	0	0	0	0
P.	7	3	0	0	0	0	0
M. B.	6	6	3	0	0	0	0
(8) F.	7	1	1	0	0	0	0
P.	33	7	0	0	0	0	0
M. B.	6	6	3	0	0	0	0
(9) F.	1	6	0	0	0	0	0
P.	25	48	9	4	0	0	0
M. B.	6	6	6	6	0	0	0
(10) F.	5	5	0	0	0	0	0
P.	8	6	2	0	0	0	0
M. B.	9	9	9	9	0	0	0

The dose in the first nine cases was six grains daily. In the tenth case it was nine grains daily.

In the next three cases fever came for a day or two after the Methylene Blue had been given.

(11) Fever	3	0	2	2	0	0	0
Parasite	6	3	1	0	0	0	0
M. Blue	0	0	6	6	6	9	0

(12) Fever	3	2	6	6	4	0	0
Parasite	2	17	23	24	11	1	0
M. Blue	0	0	6	6	6	10	6
(13) F.	4	7	1	4	0	6	0
P.	17	29	17	10	2	0	0
M. B.	0	0	6	6	6	6	6

In the next two the effect of the Methylene Blue was not at all marked. In case 15, however, the 12 grains daily seemed to have a good effect.

(14) Fever ...	4	5	7	7	5	6	0	0	0	0
Parasite ...	0	33	103	134	138	74	12	1	0	0
M. Blue ...	0	0	9	9	0	6	6	6	6	3

(15) Fever ...	4	0	5	0	5	0	6	0	2	0	5	0	5	0	5	0	2	0	0	0
Parasite ...	5	2	12.	7	20	20	6	5	2	1	5	3	10	17	14	12	2	1	0	0
M. Blue ...	0	0	0	0	6	6	6	0	6	6	6	6	6	6	6	12	12	12	12	12

The inference that may be drawn from these experiments is that Methylene Blue has undoubtedly an effect on Benign Tertian, but that in some cases a daily dose of 12 grains is required.

IN MALIGNANT TERTIAN.

The Methylene Blue was given in two cases :

(1) Fever	6	5	2	0	0	0	0	0
Parasite	3	7	1	0	0	0	0	0
M. Blue	0	6	9	6	6	0	0	0
(2) F.	5	6	5	5	4	0	0	0
P.	5	11	25	8	9	5	0	0
M. B.	0	6	6	6	6	6	6	0

The number of experiments in Malignant Tertian was not sufficient to justify us in coming to a very definite conclusion in regard to the value of Methylene Blue in this fever, but the effect on these two cases appears to have been good. Possibly the doses were not large enough.

The administration of Methylene Blue was begun with caution, because we have read that it sometimes causes irritation of the kidneys None of the patients to whom we gave the Methylene Blue suffered any inconvenience from it. It always turns the urine a deep blue colour, and it is advisable to warn patients about this beforehand.

The Methylene Blue which we used in the experiments was Methylene Blue, B. extra, and was obtained from Ostermeyer & Co., Bombay. If one-tenth of the cases of Malarial fevers in India were treated with quinine in proper doses, it is very probable that the available supply of quinine would be very soon exhausted. Methylene Blue, therefore, promises to be a very valuable drug.

CHAPTER XVI.

FURTHER OBSERVATIONS IN THE MALIGNANT TERTIAN FEVERS.

In a paper read at the Malaria Conference, and which is printed in the transactions of the Malaria Conference, a number of cases of Malignant Tertian were given in detail. These cases were not treated with quinine, and we were able to see fairly well what is the natural history of a case of Malignant Tertian Fever.

One case will be given here in order to illustrate method of keeping the records. On the top line is the day of fever: On the second line is the number of degrees of fever—decimals being omitted, and the nearest whole numbers being taken. Then the numbers of Rings, Crescents and Spheres are shown, and below is an abstract showing the total numbers of each kind of parasite in the Primary fever period, in the Crescent forming interval, and in the Secondary fever period.

The main conclusions were summed up as follows:—

(1) There is a Primary fever when Ring forms are found in the peripheral blood.

(2) There is apyretic interval, when Crescents with bellies are found and these do not turn into the Spherical forms.

(3) There is a Secondary fever and the parasites found in the blood during this part of the fever are very different from those which are found in the

No. 693 Nga Posin.

Day of fever ...	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Degrees of fever ...	**4**	**0**	**2**	**0**	**5**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**4**	**6**	**0***
			Primary fever.						Crescent interval.					Flagellar period.									
Rings ..	15	15	10	13	7	16	10	13	0	0	0	0	0	0	0	0	0	0	3	4	13	19	13
Crescents ...	0	0	0	0	0	0	0	2	10	15	11	18	15	10	3	3	4	4	8	3	3	0	0
Spheres ...	0	0	0	0	0	0	0	0	0	0	3	5	7	8	12	7	7	5	5	6	9	0	0

Abstract	Rings ...	95	0	0	0	7	45
	Crescent ...	2	36	43	10	15	3
	Spheres ...	0	3	20	26	16	9
		Five minutes examination.	Ten minutes examination.				

* Quinine gr. xx given.

Primary fever. In the Primary fever we find the asexual parasites, whereas in the Secondary fever the sexual parasites (gametes) chiefly are seen.

(4) Crescents begin to appear about the eighth or ninth day.

(5) The newly-formed Crescents do not readily become converted into spheres.

(6) There is a period of maximum number of Crescents. This occurs from the twelfth to the fifteenth day.

(7) Towards the end of the Secondary fever period (or gamete period) the Crescents diminish considerably in numbers.

(8) The spheres appear a few days after the Crescents and generally about the eleventh day.

(9) The number of spheres is at first small, but afterwards increases.

(10) There is a period of maximum number of spheres, and this occurs near about the sixteenth day.

(11) The period of maximum number of spheres follows the period of maximum number of Crescents.

(12) After the period of maximum number of spheres the spheres diminish in numbers, and at the end of the Secondary fever (gamete period or flagellar period) only comparatively few are found.

(13) The period of maximum number of spheres coincides in a remarkable way with the Secondary fever.

(14) Ring forms are not usually found in the blood in the Secondary fever period. (There are, however, some exceptions to this rule.)

(15) There is no doubt that the withdrawal of the blood from the body hastens or brings about exflagellation.

(16) Phagocytes will never attack Crescents as such *in vitro.*

(17) The Crescents (gametes) are in some way destroyed inside the body.

(18) The absence of Ring forms in so many cases in the Secondary fever, the close relation between the period of maximum number of spheres and the Secondary fever, and the fact that Crescents and spheres are reduced in numbers after the Secondary fever, tend to show that the Secondary fever is probably in some way related to the breaking up of the Crescents inside the body.

(19) The actual nature of the process of breaking up is not definitely known.

TERMINOLOGY.

The term gamete is applied to the sexual forms of the parasite. In the Malignant Tertian the gamete is at first crescentic in shape and is often spoken of as a Crescent. When the Crescent is converted into the spherical form it becomes what is called the spherical gamete, or sphere. The term flagella bodies which we formerly applied to these is objectionable, because only the males give out flagella.

The Malignant Tertian fever is a very remarkable disease. There is probably no other febrile disease in which part of the fever is caused by asexual parasites, and another part by sexual parasites.

A discussion followed this paper in which several members of the Conference took part. A brief extract from the Proceedings of the Conference is given below :—

Dr. Christophers remarked that Major Buchanan's charts and parasite counts had shown the course of a Malignant Tertian infection to be a definite one. He was extremely interested to note Major Buchanan's observation that a secondary rise of temperature almost invariably takes place some days after the defervescence of the fever; also that Crescents for three or four days after their first appearance do not change into spherical bodies or flagellates, but do so after this period. The period during which large numbers of spherical bodies are present was also very striking. What the nature of the secondary rise of temperature may be did not seem very certain.

Captain Glen Liston, I.M.S., said:—

"I think that apart from theories Major Buchanan's work is of great importance. He has shown that for a time Ring forms alone are found in the blood of Malignant Tertian fevers, that about the 9th day young Crescents are found, that later the mature gamete is abundant, and that at this time fever generally occurs. Still later the gametes disappear, and the fever also comes to an end.

"He plainly shows that the Secondary fever is due to the presence of mature gametes. This is all the more important when it is considered that some writers had expressed the opinion that gametes do not play any part in the production of relapses."

Mr. Powell, F.R.C.S., said:—

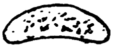
"To Major Buchanan was due the credit of determining the period of maximum sexual activity. He thought it was the rule rather than the exception to find Rings during the Secondary fever."

NOTE.—We have found some cases in which Ring forms are found during the Secondary fever, but possibly there may have been a double infection in those cases.

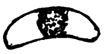
CHAPTER XVII.

THE SEX OF CRESCENTS.

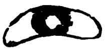
The chief distinguishing mark between the male and female Crescent lies in the arrangement of the pigment. In the male, the pigment is more scattered throughout the body of the Crescent,



and in the female the pigment is collected together into the central part, sometimes into a little clump without any vacant post in the centre,

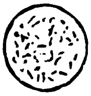


and sometimes with a central space free from pigment.

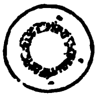


The pigment in the males is perhaps a little coarser.

When the Crescents are converted into the round forms (spherical gametes) it is much easier to tell the male from the female. In the male before the flagella have been extruded the pigment is scattered about all over the sphere while in the female we find an inner



circle and outer circle, and the pigment is chiefly arranged at the circumference of the inner circle.

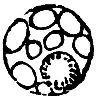


Two or three dark granules are seen in the space between the inner and outer circles, and these are generally dancing about.

Female Spherical Gamete.

We have recently given a good deal of attention to the female spherical gamete, and she has been the source of a considerable amount of discussion, and also some differences of opinion.

We had noticed in some Malignant Tertian cases, about the third week or later, a curious form of parasite which seemed to have a number of what looked like spores inside it,



and although in a picture it may look like a Rosette still the real parasite looks very different. The arrangement of the pigment led us to suspect that it was a female spherical gamete. For some weeks we wondered what this could be and asked many of those who are interested in Malaria if they had seen it. We considered the possibility of its being a sporulating form, and as the first cases in which we found it happened to have the Ring forms again returning into the blood about the 20th day of the fever, we discussed the possibility of this curious form of parasite being a stage in the sexual reproduction of the parasites within the body.

A few days afterwards we were watching a female Crescent and saw it change into the spherical form. After about half an hour it changed into the curious form referred to above and it seemed to be filled with what looked like spores ; but occasionally two of these would join together and form one. We concluded then that they could not be spores and that they must be vacuoles ; we were able to find these vacuolating females, as we now call them, often, and have shown them to several members of the Malaria Conference.

Since the above observations were made, we have read the excellent paper, that appeared in the Malaria Number of *The Practitioner*, by Dr. Sambon, and were much interested to find that the Italians had already experienced similar difficulties. Some described these bodies as "sporulating Crescents," but later Marchiafava and Celli were of opinion that they are vacuolating spherical gametes.

After Ko Tha Aung had been working at this point for some time, a letter was received from Major Ross in which he gave a description and illustrations of the males and females in the Crescentic and spherical forms. The illustrations given by him of the Crescents and spheres are very much the same as we have given here.

CHAPTER XVIII.

OBSERVATIONS IN NIMAR.

In June, July, August and September 1902, we had an opportunity of making some observations in Nimar, a District in the North of the Central Provinces. The Head-Quarters station, which is at Khandwa, has a reputation for comparative freedom from Malaria fevers, while there are some parts of the District which are notorious for their unhealthiness.

In June it was only after searching for several days that we were able to find any anopheles in Khandwa. The rains began towards the end of June, and then the anopheles began to be abundant. The Rossii are the most prevalent, but Culicifacies are also found. Chandni, a small station on the G. I. P. Railway, is notorious for its Malaria fevers, and it has been customary to supply drinking water for the Railway staff from one of the adjacent stations. There is a small stream about a hundred yards from the station, in which we found many anopheles larvæ in August. About six miles from Chandni is the famous old fortress of Asirgarh, and in the fever season few of the inhabitants of the little village which lies at the base of the hill on which the fortress is built escape fever. Here thousands of anopheles larvæ were found in August. Many of these were Culicifacies, but there were a great many of a new species which we had not hitherto seen. On the proboscis there are three bands, but unlike any that we had already seen the terminal band is broad, the middle one of medium size, and the basal one is narrow. It is a small rather dark mosquito, tarsal joints banded. Third longitudinal mostly white, legs not speckled. We have not yet had an opportunity of enquiring how far this new species is a carrier of Malaria, but the finding of this species in a notoriously malarious place tends to throw suspicion on it as a carrier of Malaria.

Quartan fever.—The long duration of Quartan was well illustrated in the case of a woman who had, with the exception of occasional intervals, been suffering from Quartan fever for eight years. Particular enquiries were made from her friends in regard to the duration of the fever, and there seemed to be good reason to believe in her statement. Twenty grains of quinine was given and the fever was stopped. This is the only case of Quartan that we have seen in Nimar.

Benign Tertian.—In June three cases of Benign Tertian were found. In July seven cases were found, and in August they are becoming more numerous *Malignant Tertian.* Up to date (middle of August) only five cases of Malignant Tertian have been seen. These observations tend to confirm what had been found in Nagpur, *viz.*, that the Benign Tertian is an Autumn fever and that it prevails before the Malignant Tertian.

Enlarged Spleen.—A good many cases of enlarged spleen have been found. Although no accurate statistics have been prepared on this point, we are inclined to think very marked enlargement of the spleen is more often associated with Benign Tertian parasites. Every one is familiar with the old established treatment of enlarged spleen. We asked a Hospital Assistant if he believed in its efficacy, and he expressed some doubt on the matter. He had a number of cases that he was treating, and they were deriving very little benefit from the treatment. He, however, was carrying out the treatment in only a nominal and half-hearted manner; the iodide of mercury was applied in small quantities and occasional small doses of the sulphates mixture was given. Ten cases were picked out and treated thoroughly, with the result that the spleens were reduced very considerably in a few weeks.

The first essential in treatment is to kill any parasites that are present in the blood with Quinine. The iodide should be rubbed in, preferably in the sun, over a large area, and in sufficient quantity to blister the skin. The mixture containing Ferri Sulph., Quinine Sulph., Sulphuric Acid and Magnes. Sulph. should be given in sufficient quantity to make the bowels move three times a day.

Campaign against Anopheles.

We are at present engaged in carrying out a campaign against mosquitoes in two of the principal towns of Nimar—Khandwa, 18,000 population, and Burhanpur 30,000. Owing to defects in the drainage systems in these two places complete success can scarcely be expected at once, but there is no doubt that the numbers of anopheles will be enormously diminished, and it is hoped that the number of cases of Malaria fever will be proportionately diminished.

A word about Ko Tha Aung before concluding. He was released from prison by Government of India on the recommendation made by the member of the

Some hold that the hæmoglobinuria is due to a large dose of quinine. The black water usually comes on the second day, and patients on getting an attack of fever take quinine, so that a dose of quinine will often have been taken before the black water appears ; but Dr. McCutcheon's cases show clearly that quinine is not the cause, and Dr. Newell states distinctly that he had not taken a large dose of quinine before the black urine appeared.

Some think that the disease has been recently introduced into the Duars, but others say it has been occurring there for many years but has been generally called "Jaundice."

Severe headache : intractable vomiting : great prostration : slow recovery : and abdominal tenderness seem to be leading symptoms. The disease is one which requires to be carefully studied.

APPENDIX II.

MALARIA IN CYPRUS.

DR. GEORGE WILLIAMSON, of the Colonial Medical Service, gives an account of the Malarial Fevers in Cyprus in the *British Medical Journal* of 27th October, 1902. In a year's observations he found the percentage of the different varieties as follows (decimals omitted): Benign Tertian, 48 ; Quartan, 8 ; Malignant Tertian, 43 ; and the season of occurrence was as follows :—

1901 : February, 11 ; March, 9 ; April, 5 ; May, 6 ; June, 9 ; July, 101 ; August, 87 ; September, 94 ; October, 60 ; November, 24 ; December, 32 ; and January, 32, 1902.

The maximum occurs in July. The rainfall in May was 4·52 inches, and in December it was little over half an inch ; in the other months it was less than an inch.

Dr. Williamson gives charts to show the seasonal prevalence of each kind of fever. The Benign Tertian begins in June : attains its maximum in July and falls to zero after October. The Malignant Tertian begins in June : maximum in September. The number of Quartan cases is very small. These observations tally in a remarkable way with the Nagpur observations, if we allow for the earlier rainfall in Cyprus.

MALARIA IN ASSAM.

Dr. Bentley has sent me a note of his observations in Borjulee, Tezpur, Assam. In 300 cases in which he found parasites there were Quartan 46 ; Benign Tertian 134 ; Malignant Tertian 74 ; Rings only 46 (in these last it was impossible to decide with certainty). All the children between one and three have parasites : those under one year seem to be free at the time of the year when he wrote (February). In one garden the percentage of children infected was 100 and afterwards 92. The lowest percentage in any garden in that District was 40 per cent. He has not found parasites in recent cases of Kala-Azar. He has only found malarial parasites nine times in the blood of 159 cases of Kala-Azar that he has examined in the past three months. Quinine cleared away the parasites without affecting the Kala-Azar. These facts, says Dr. Bentley, entirely preclude the malarial origin of Kala-Azar. I have quoted very briefly from Dr. Bentley's letters, but I hope he will not hide his valuable work under a bushel.

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